METAL PROGRESS

DECEMBER 193

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TIMKEN

Electric Furnace and Open Hearth

ALLOY STEELS

Robert G. Guthrie

J. A. Comstock

W. M. Peirce

J. W. Harsch

Jules Muller

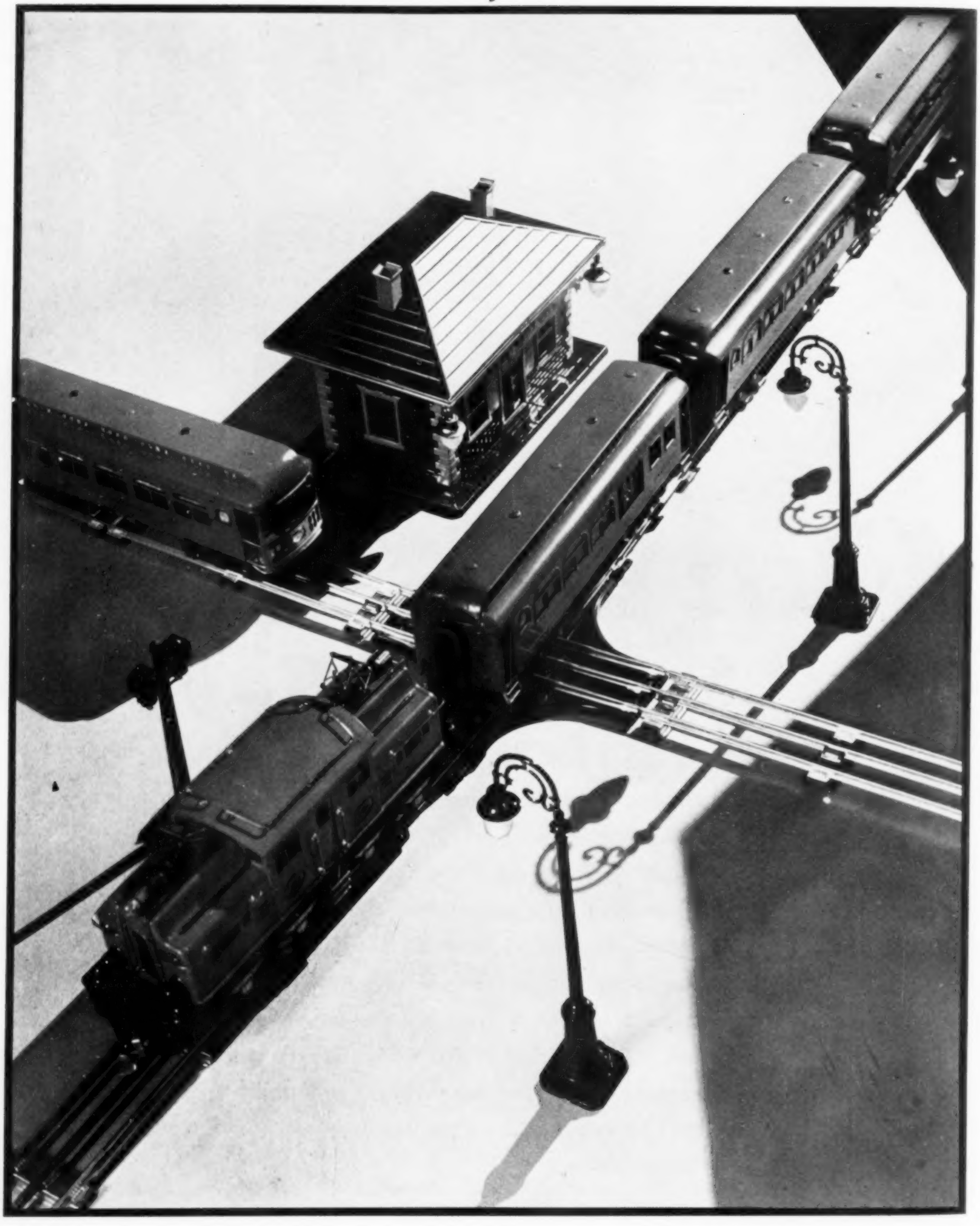
In This Issue

Well known to American Society for Steel Treating members are Robert G. Guthrie and J. A. Comstock, whose article on automatic polishing for metallographic inspection begins on page 59. Mr. Guthrie was president of the Society in 1930 and is chief metallurgist for Peoples Gas Light and Coke Co., Chicago. Mr. Comstock has been secretary-treasurer of the Chicago Chapter since 1927, and is assistant metallurgist for the same organization. Both also serve as consulting metallurgists.

Two graduates of the University of Illinois, who are now associated with Leeds and Northrup Co., collaborated in writing the discussion of nitriding containers which begins on page 41 of this issue. John W. Harsch, assistant chief engineer of the company, holds the degree of Bachelor of Science in Chemical Engineering. His co-author, Jules Muller, development engineer in charge of the furnace division, is Bachelor of Science in Mechanical Engineering. Both Mr. Harsch and Mr. Muller were engaged in various phases of metallurgical research before assuming their present responsibilities.

The discussion of zinc-base die castings on page 53 was prepared for the Recommended Practice Committee of the American Society for Steel Treating and the Non-Ferrous Data Sheet Committee of the Institute of Metals, American Institute of Mining and Metallurgical Engineers, by W. M. Peirce, chief of the metal research division of New Jersey Zinc Co., and Marc Stern, manager of the die casting division of A C Spark Plug Co.

One of Metal Progress' regular contributors is Dr. Kotaro Honda, whose monthly letters from Japan have recorded many interesting developments by metallurgists of that country. Dr. Honda is a graduate of Tokio University and received his doctor's degree from that institution in 1902. In 1907 he was appointed by his government as research fellow abroad and for four years he traveled and studied in Germany, France, and England. In 1911 he returned to Japan as professor of physics in Tohoku University, Sendai, Japan. A few months ago he was elected president of Tohoku. In 1922 Dr. Honda was awarded the Bessemer Medal of the Iron and Steel Institute of Great Britain, and in 1925 he received a gold medal from the Japanese Iron and Steel Institute for his investigations. He is a member of the A.S.S.T. and has been on National Metal Congress programs.



It Makes a Boy of Dad

MODEL RAILROAD TRAINS

need many modern alloys

ONCE the idea of making toys that work rather than toys just good enough to sell gets hold of an organization, it avoids buying the lightest tin that can be clinched together and finds itself using the most advanced alloys and metallic products: Stainless steel, transformer sheet, brass, copper die castings, bronzes, nickel alloys — even sterling silver where satisfactory service demands it.

Such intelligent use of present day materials of construction, modern production methods, engineering design applied to the manufacture of model railroad trains, characterizes the plant of Lionel Corporation, Irvington, N. J. Sheet steel is, of course, the most important raw material going into the 300 or more separate items manufactured here, all appertaining to model railroads or accessories, such as station houses, semaphores, bridges, trackage. It is exclusively full finished automobile sheet, of deep drawing quality. Engine bodies and car frames are made of 22-gage material; some 26-gage sheet is used for interior trim and for minor station buildings. Deep drawing quality is insisted upon to withstand the drastic press work which is needed to form some parts. Full finished stock also insures that the enameled parts will come out of the oven with lustrous, perfect finish. A minor number of stampings could be made of a second grade material, but in order to avoid the possibility of mixing, only the best is purchased. As an indication of the size and power of the machinery used for cutting and flanging the largest of the units, it may be said that when recently a small-sized electric range was put into production, no additional presses were required to handle the $\frac{3}{32}$ to $\frac{1}{8}$-in. steel plate.

Much cold rolled strip is also consumed, in thicknesses varying from 0.020 in. up to 0.078 in. Since many of the parts punched from this material must take a square bend or a deep impression, it is in the soft or half-hard condition. Parts like couplers, car wheels, driving wheel tires, piston rods, connecting rods, valve gear mechanism, side frames for motor assemblies, railroad ties — all are made of cold rolled strip in tinned or nickeled finish.

Railroad rails are made of prime tin plate of a weight which approximates 26 gage. Sheets

Joints in Sheet Metal Parts Made by Clinching Lugs and Welding Corners

of correct size are cut into strips by a gang slitter, and then passed through a series of forming rolls which curl and bend it into the outline of a regular railroad rail. A unit of track consisting of two running rails and the third rail, when clinched to the pressed steel ties, will stand the weight of a 300-lb. man without collapsing. Lionel trackage is therefore much superior to the flimsy stuff formerly sold with many mechanical toys, which only required one small person to stumble over it to ruin it for further train operation.

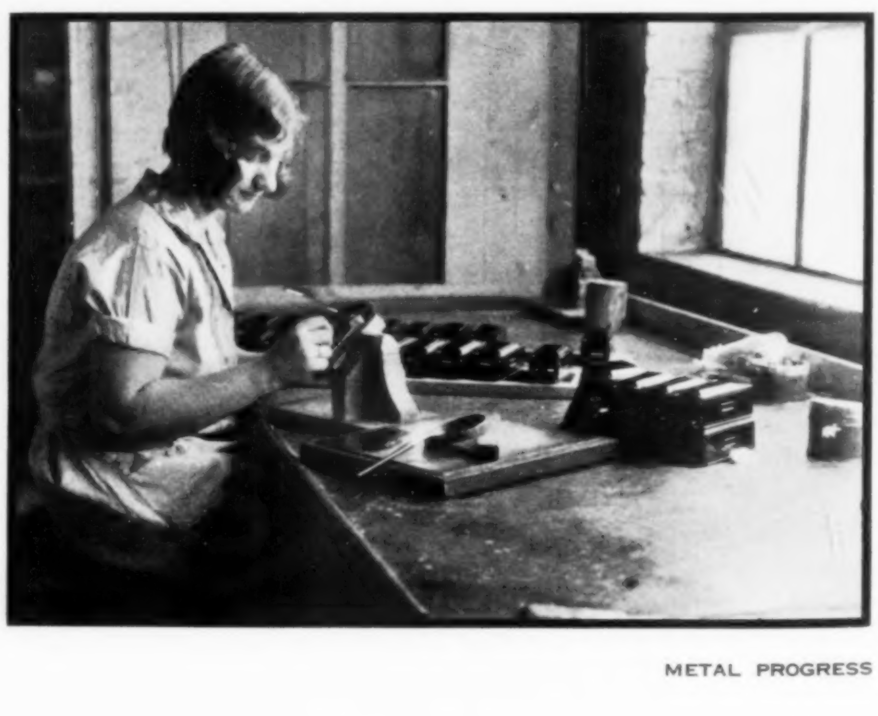
Car bodies generally are made of sheet steel. Some of the more elaborate tender bodies ("coal cars") are aluminum die castings.

Lightness is an important feature in the weights that have to be hauled — locomotives, however, need weight in order to develop tractive power. Consequently, the main frames are stout zinc-base die castings, or, if of pressed steel, are counterweighted with laminated plates. Driving wheels are also zinc-base die castings. (A ferrule of cold rolled strip, nickel plated, is pressed over the wheel tread to avoid wear.) Cylinder and steam chest castings are of aluminum, to avoid a concentration of weight near the front of the engine which might cause derailment when taking a curve at speed.

Another instance of how the distribution of weight must be studied in order to get good running characteristics may be found in the small derrick car, or "wrecker." It has three motions — slewing, boom up, and hoist — each of which is driven through die cast helical gearing from a hand wheel at the rear of the cab. Originally, these hand wheels were solid brass, about the size of a 25¢ piece and three times as thick. But the weight of these hand wheels, together with that of the boom, put the center of gravity so high that the car would sometimes jump the track on curves. Substitution of aluminum for the brass hand wheels was just enough to make the difference between success and failure of this design.

And it should be noted that the ball on the hoisting hook on this derrick is *lead* — weighty enough to overhaul the line when the hoisting drum is turned!

Advanced die casting practice is necessary to produce some of the accessories. For instance, a lamp post may be made of a bent



Enamelled Car Bodies Getting a Striping of Color to Accentuate the Trim and Add to the Eye Appeal

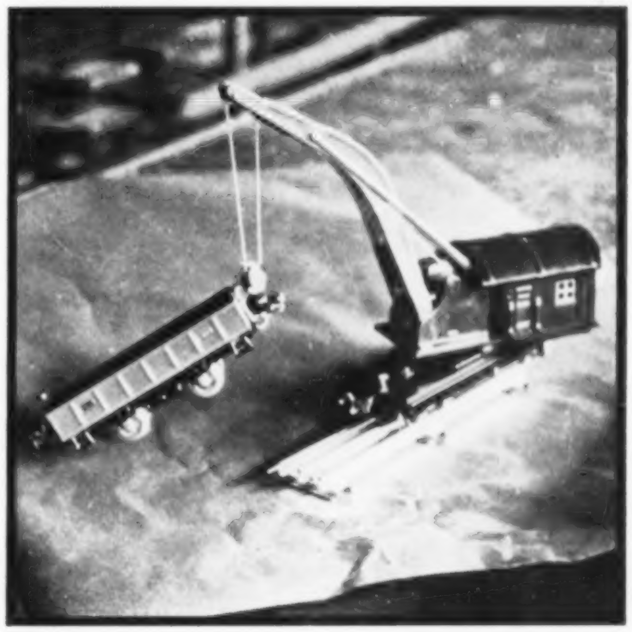
piece of brass tubing, inserted in the die, and a base cast on one end simultaneously with some graceful ornamentation at the bend near the top. Such a simple thing as a headlight has an internal thread to fit the miniature electric globe, and two cores at right angles, one for electrical wiring, the other for a set screw holding the light to a bracket. A photograph of the headlight appears on the next page.

As remarked above, car bodies are usually of steel stampings. Joints are ordinarily made by slipping little dog-ears through slots in the mating parts and clinching them down in a press. Frequently this construction is stiffened or reinforced by soldering or welding.

Entire units have a baked enamel finish. Trimmings are attached separately. For instance, name plates are of etched brass strip, slipped through appropriate slots and clinched on. Window and door frames are lacquered brass stampings, securely attached inside to corresponding openings in the side walls. Journal boxes are nickeled brass, separately fastened in place. Handrails on engines and passenger cars are brass wire. Car steps, air reservoirs, steam chests, smoke pipes, all are stamped from brass sheet, lacquered, and separately affixed. Steam pipes are copper.

Such detail not only is extremely realistic, but the color is permanent.

Motors and electrical control on Lionel trains are most ingenious. Armatures and pole pieces are laminated, consisting of a series of punchings. A battery of gear hobbers cuts all the teeth on the main drive; master gear is bakelite for quiet running, others are of cold rolled strip. All armature shafts are hard drawn drill rod; bearings are bronze bushed. Axles on drive wheels are of needle-bar stock for smooth finish, and run in stainless steel bearings.



Wrecker Has Aluminum Die Castings In Upper Works to Keep Center of Gravity as Low as Possible

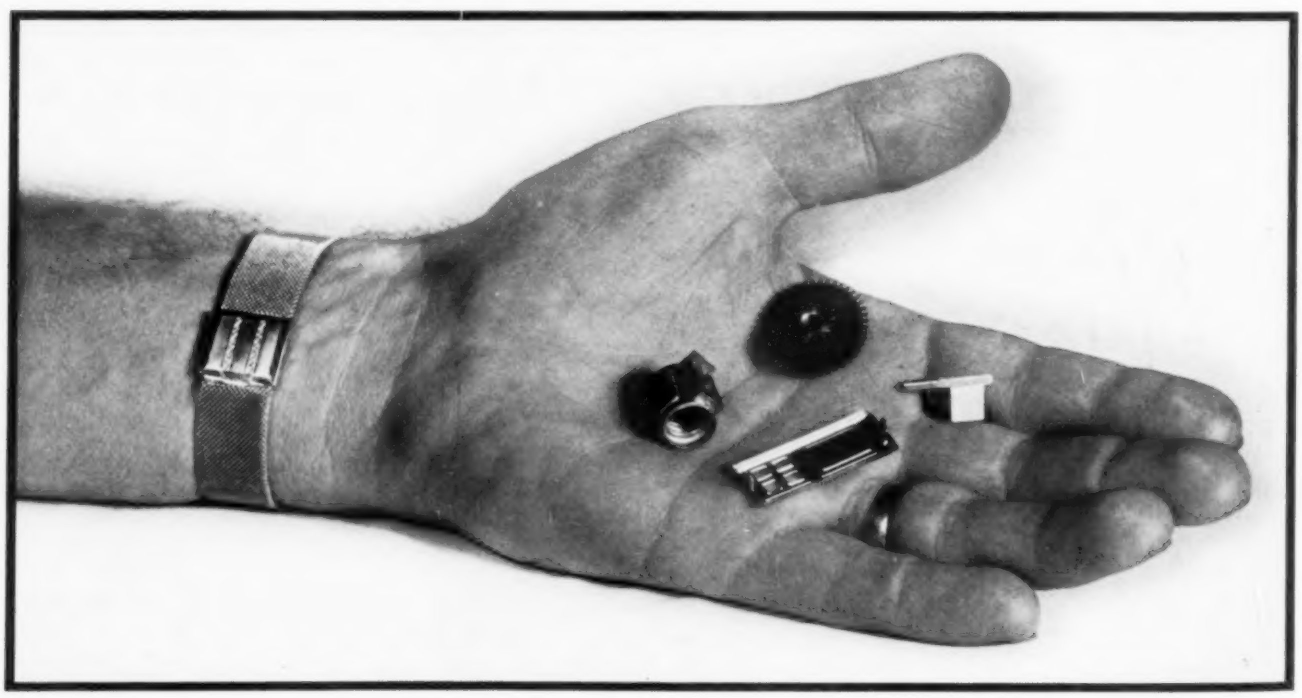
Electric shoes are also stainless steel rollers. This expensive alloy is used to collect and return current because it resists pitting from the electric sparks, and wear from frictional contacts.

Other metals used in Lionel locomotives and cars are phosphor bronze contact springs to hold the electrical contact shoes to the third rail, bessemer rod for car axles, copper plate on commutators, silicon steel for transformer laminations, silk wound magnet

In this Progressive Generation Santa Claus' Helpers Use All the Tools and Metals of a Modern Automotive Plant

wire for windings, piano wire springs and small parts of brass and screw machine stock. In one reversing mechanism, for remote control train operation, three binding posts are of nickel-silver, but the moving finger is of sterling silver — nothing less expensive will resist the sparking effect satisfactorily for long operation. Much brass strip, ranging from 0.015 to 0.062 in. thickness, is used for trim (when it is lacquered after forming), and for many motor parts (where it is selected sometimes for its electrical characteristics and sometimes to enhance the appearance of quality).

Model Railroad Trains, Trackage, Wayside Structures and Signal Systems Use Numberless Tiny Parts. Accuracy of detail and satisfactory operation require high precision



Motor parts are made with precision. Drive wheels are drilled in pairs in a jig to insure that the connecting rod will not bind. No sticking or binding can be tolerated in solenoid operated switches, semaphores and other accessories, so they are made to a precision of 0.0005 to 0.002 in., plus or minus. As remarked before, gear teeth are machine cut.

Manufacture of these toys gives ample scope for the production expert to exercise his ingenuity. Take the signal flag. In railroad parlance, all Lionel trains are "extras," so in conformity with railroad signaling, they carry white flags, two on front and two on rear. These formerly were made of a small square of celluloid, cemented to a flag-stick of brass, threaded at the lower end to screw into the appropriate socket.

Made in this manner they were expensive, and not very durable.

Now they are made of thin sheet steel; flag and stick are blanked and the stick curled in three operations. White enamel, baked on, completes the job. The stick is a tiny split cylinder, with just enough spring in it to be held securely when thrust into a smooth socket.

Many machine operations were saved, and the part is cheaper and better.

NITRIDING CONTAINERS

high nickel alloys best

by J. W. Harsch
and J. Muller
Leeds & Northrup Co.
Philadelphia

NITRIDING is essentially a chemical process in which a reaction between an alloy steel and ammonia takes place at elevated temperatures.

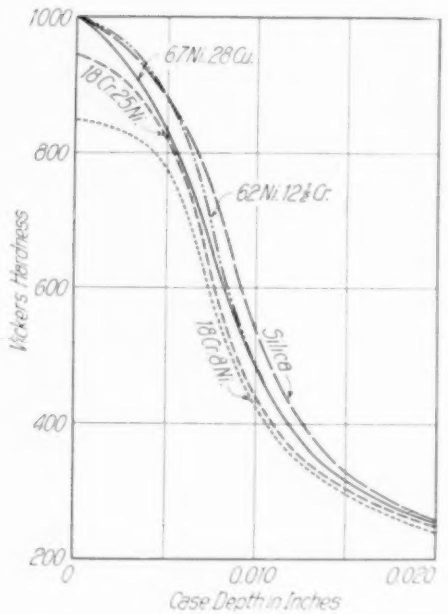
When ammonia at atmospheric pressures is subjected to temperatures above 842° F. it dissociates into its constituents, hydrogen and nitrogen. If this dissociation takes place in contact with suitable steels at a temperature at which the steel can absorb nitrogen, the various iron nitrides which will be formed at the surface will diffuse inward into the steel. The depth of penetration of these nitrides will be dependent upon the temperature, the time of the cycle, and the concentration of the available reactive agent in the furnace.

In ordinary steels, we are accustomed to seeing the nitrides in the form of nitride needles. Such nitrides are detrimental as they are brittle and constitute cleavage planes of very low shock resistance. Special steels have been developed which will absorb nitrogen without forming undesirable nitride needles, such nitrides being in a form which imparts desirable properties (especially hardness) to the material.

The nitriding reaction must necessarily be carried on in a gas-tight container as the necessary ammonia gas is objectionable in the atmosphere, even in small percentage, and the question of suitable containers is of great importance to the furnace manufacturer. Most of the laboratory nitriding tests made during the development of the process were carried on in closed retorts, but during this period of development very little thought was given to the materials used for retorts or to the construction of reaction chambers. After the nitriding reaction had been studied in small units and the influencing factors recognized, the principle involved was introduced into larger furnaces. These early nitriding containers were made of various materials.

Some of the first were fabricated of low carbon steel. Low carbon steel, with which we are all familiar, will oxidize and nitride at temperatures of 900 to 1160° F. when subjected to the respective atmospheres and, therefore, has a very short life. It absorbs reactive nitrogen quickly at these operating heats. When nitrided, its surface becomes embrittled and, as the nitrides formed have little mechanical or shock strength, the container soon fails.

A low carbon alloy having chromium up to



Some Materials, After 1500 Hr. of Service, Affect Nitriding Reactions so That Maximum Surface Hardness Can no Longer Be Procured. Curves represent depth-hardness figures for steel nitrided 24 hr. at 1000° F.; average flow in all experiments, 26 liters per hr.

13% was then tried as a substitute. Low carbon chromium-iron has heat resisting properties and it was anticipated that its life would be longer and would warrant the extra cost. However, it was a disappointment, as its life was very little longer than that of low carbon steel.

18-8 Containers Tested

The more complex alloy containing 18% chromium and 8% nickel was then substituted. Such material is better suited for service at elevated temperatures, and, therefore, it was thought that this material would have the necessary life in ammonia atmospheres. However, this also proved to be a misconception.

The containers made of the 18-8 produced work of acceptable hardness for a few heats, but then it became apparent that the process was being disturbed by some factors which affected both the case hardness and the penetration. The difficulties formerly experienced with the life of the containers — insofar as the mechanical strength was concerned — were matters of selection of suitable materials, but the loss in hardness and penetration was not fully understood and it required time-consuming tests to verify this effect.

In view of the recorded failures, investigations were begun in an endeavor to solve the question of materials for nitriding containers and simultaneously to determine the deleterious effect of the various metals upon the nitriding reaction. Materials of the following compositions were studied: 18% chromium and 8% nickel; 18% chromium and 25% nickel; 67% nickel and 28% copper; 62% nickel and 12.5% chromium; and an inert material such as fused silica. Nitriding containers of each were built and placed under nitriding tests.

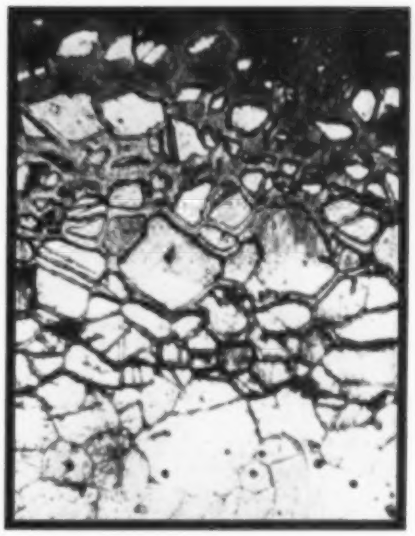
The nitrided cases produced on proper steels placed in the various containers during the early stages of the tests were of practically the same hardness and penetration and at that time very little preference could have been expressed for one material over the others. However, as the tests progressed the disturbances in the process previously noticed were again encountered.

A series of hardness-penetration curves shows the type of case obtained when nitriding in the various containers after the latter had been subjected to a nitriding atmosphere and temperature for nearly 1500 hr. The reactive agent was dissociated to different amounts even though an equal flow of gas passed through a constant amount of work within all containers. This fact showed a reaction between the chromium-nickel-iron nitriding containers and the ammonia, which resulted in the formation of nitrides in the container wall. The depth of penetration of the nitrides formed on the walls of various containers is shown in accompanying photomicrographs.

Further investigation led to the conclusion that the nitrides formed on the container acted as a catalyst and soon depleted the nitriding atmosphere of the necessary reactive agent and increased the dissociation of the ammonia. With continued use of the furnace, more and more of the nitriding gas was wasted by this parasitic reaction and less and less was usefully employed in nitriding the object or work placed within the furnace.

The nitrided work from the container most susceptible to nitriding (18-8 alloy) showed low hardness and penetration. Containers made of 62% nickel and 12.5% chromium, of 67% nickel and 28% copper (monel metal), and of inert material produced the best nitrided cases. These tests definitely established the value of some high nickel alloys as suitable materials for nitriding containers, and conclusively indicated

that the reaction taking place in a container made of some inert non-metallic material will produce surface hardness and depth of penetration which are comparable to the best produced in any metallic material used, and that such inert materials are highly desirable for nitriding containers and should be preferred to metals.



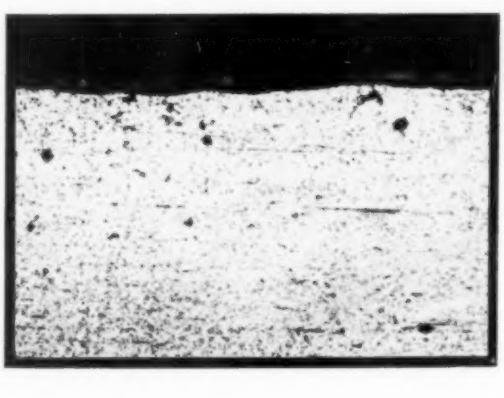
Monel Metal With High Manganese Suffers Severe Intercrystalline Attack by Nitriding Gases, But the Nitriding Reactions Are Not Delayed

High Nickel Alloys Satisfactory

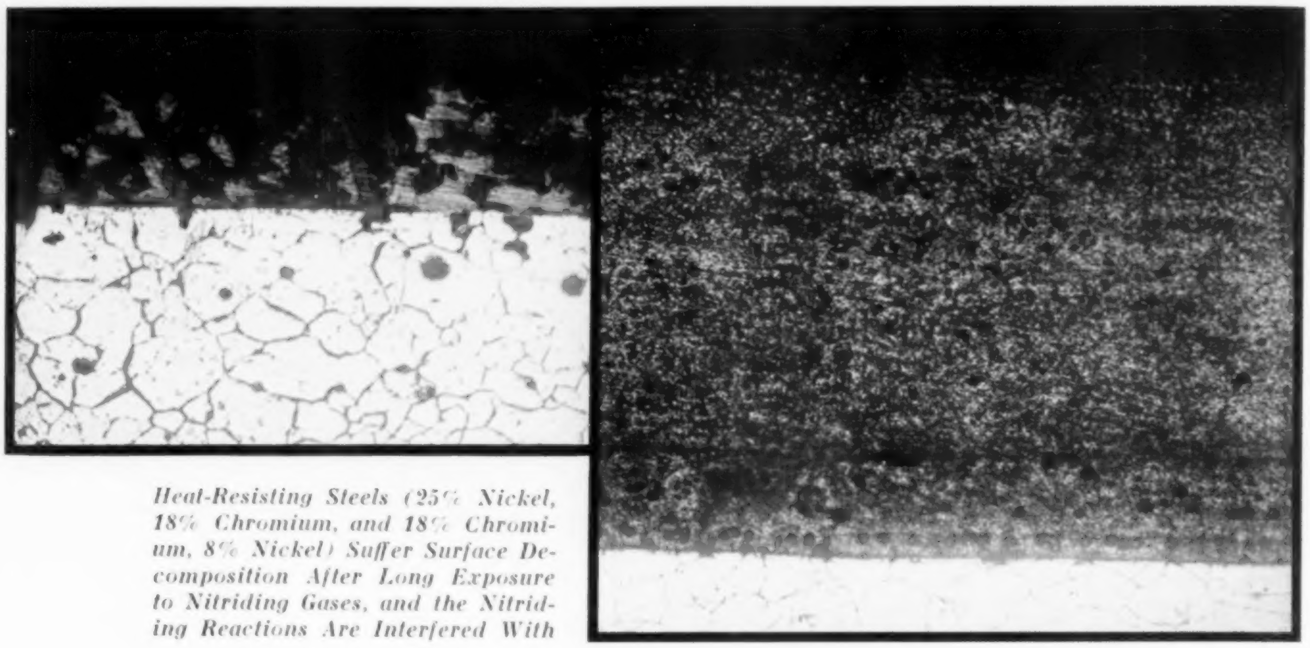
A further study was made with a material which would resist the nitriding action of atomic nitrogen. The material selected was sufficiently high in nickel to resist nitriding, sufficiently high in other components to prevent the embrittling action found in pure nickel, and was preferably substantially devoid of constituents reacting with atomic nitrogen or acting in this relation catalytically. Nickel-chromium and copper-nickel alloys were found to be satisfactory. The nickel content of these alloys was well above 60%.

Nickel-copper alloy having more than half of one per cent manganese was found to be unsuited for nitriding containers. This material is shown in one of the photomicrographs, from which it is evident that the impurities, such as manganese, found in the grain boundaries of this alloy, react with the nitriding atmosphere. Under continued exposure, the grains found near the surface will be completely disintegrated. The test made in containers of this nickel-copper alloy showed this deterioration has practically no catalytic action upon the nitriding reaction. The only harmful effect which we find is that the material, after being subjected to repeated nitriding operations, becomes porous and of very low mechanical strength, especially at and near the welds. Material of the same composition and of low manganese content (0.50% or less) has been found to be better suited for nitriding containers; it has a longer life and does not show intercrystalline deterioration.

Other investigators have used containers made of inexpensive low carbon steels upon which a suitable enamel coating was placed. The enamel presented an inert surface to the nitriding atmosphere, somewhat analogous to a fused silica container. The idea of an enameled container for this purpose was new and many users of containers made of unsatisfactory metals attempted to lengthen the life of their respective containers by enameling them. Such procedure was not particularly successful, because the gases within the steel would produce sufficient pressure upon the enamel coating to blister and crack it, and thereby expose the metallic part of the container to the furnace atmosphere. The mechanical strength



Nichrome (62% Nickel, 12.5% Chromium) and Monel Metal (67% Nickel, 28% Copper, Low in Manganese) Are Practically Unaffected After 1500 Hr. of Nitriding



Heat-Resisting Steels (25% Nickel, 18% Chromium, and 18% Chromium, 8% Nickel) Suffer Surface Decomposition After Long Exposure to Nitriding Gases, and the Nitriding Reactions Are Interfered With

of the enamel at room and at elevated temperatures must be carefully considered. Careful handling of the steel parts to be nitrided during the loading and unloading operations is required. If the enamel coating is once broken, the action of the gas upon the metallic surface will be similar to that described above for unprotected metals.

Metal containers made of materials of suitable nickel and chromium content are necessarily expensive, but their cost is well warranted when the life and the effect of such materials upon the nitriding reaction is considered. The tests have shown that an alloy containing 62% nickel and 12.5% chromium is best suited and the 18% chromium 8% nickel alloy the worst of the metals tested.

Consideration must also be given to the method of fabrication. If the container is to be fabricated by welding, it is very important that the composition of the material be such that no elements are volatilized or oxidized during welding, and the composition of the weld be such that it causes no later troubles of the type discussed. Moreover, the material forming the weld is essentially a cast material, and the effect of the temperature gradient in the material and weld, prevailing during welding, must be recognized. This may cause a grain growth in the parent material, and such coarsened structure may have an affinity for reactive gases or be susceptible to deterioration by such reactive gases. The combined effect may considerably shorten the life of the container, even though the parent material is of suitable analysis.

Effect of Furnace Design

The material best suited for nitriding containers is determined by the type of furnace for which the container is designed. An outside-fired container must necessarily be made of metals, with or without an enamel coating. (It is recognized that metallic containers are never completely inert to ammonia. Although the catalytic action of the material described as suitable for nitriding containers is reduced to a minimum, such action is present.)

From the foregoing it is apparent that seal or caulking welds should be kept out of the reaction zone and that inert materials should be used whenever possible. While the use of metals is still common, the result of our tests has indicated the desirability of an inert material in the form of semi-refractory insulating bricks. Such a construction is now standard in the convection type heating furnace manufactured by the writers' firm. A welded sealed metal container is placed *outside* of the temperature zone, which practice eliminates metal and seal trouble as well as the parasitic reaction mentioned above.

MODERN HEAT TREATING

in truck manufacture

by Fred C. Smith
Metallurgist, Fort Wayne Works
International Harvester Co.

CONSTRUCTION of the International Harvester Company's Fort Wayne, Ind., plant was begun in 1921. Its purpose was to replace the older Akron, Ohio, plant with a manufacturing institution of more modern design and equipment, capable of making trucks of the highest quality and with reasonable economy of manufacturing cost. The original plan was to produce only heavy duty trucks in the new plant, but with the trend of the demand toward a lighter vehicle for some jobs, the company has kept pace with the market and certain lighter trucks have been added to the line.

As a part of the general plan, the heat treating department was originally placed near the center of the plant, in order to minimize the distances through which work had to be moved to and from the machining departments. The equipment installed was of late design and considered to be very good at that time (1921). The set-up for control and supervision was considered excellent and the final product compared favorably in a metallurgical way with any similar line in the country at that time.

However, the amount of work which the heat treating department was required to process increased by leaps and bounds, and equipment and controls considered modern in 1923 were obsolete in 1928. A new building was needed, giving larger floor space to house the latest equipment, having a capacity far in excess of the former installations. Consequently, a new building was erected, 120x300 ft. in size, with roof of sawtooth design and with a basement under part of it to handle certain phases of the work. An auxiliary building was constructed near by to house pickling and tumbling equipment and to act as a storehouse.

Both buildings were placed near the forge shop, since a very careful survey of production has shown that the larger tonnage to be heat treated came from the forge shop, and that the cost of trucking would be less in the location chosen. A very few of the better furnaces were moved from the old to the new location and much new equipment was purchased to make a well-balanced unit. The use of fuel oil was discontinued and the furnaces in the new location were heated with gas or electricity.

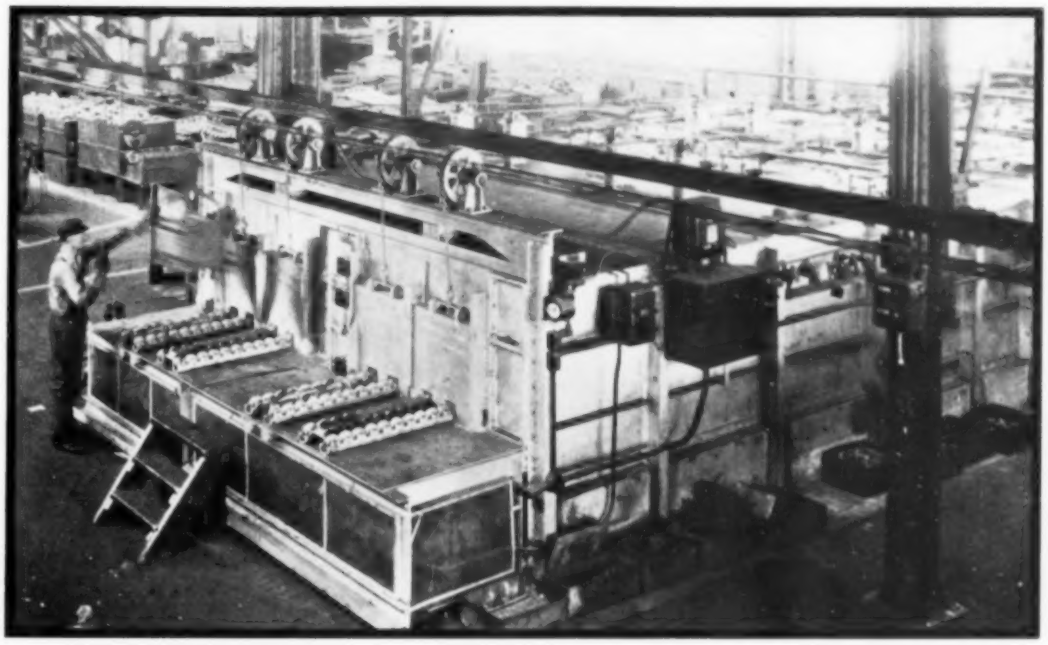
The resulting installation is a department notable not only for its size but for its

cleanliness and orderly arrangement. All the furnaces were constructed by manufacturers of national reputation and the controls were made by one of the country's leading makers of such equipment. While money was not wasted, no expense was withheld if it was felt that such expenditures would result in a better product. Neither was the comfort of the operators overlooked. For instance, the loading and unloading of carburizing boxes, together with the reclaiming of the old compound, is handled in the basement, connected directly and wide open to the main building. Smoke and dust control is so efficient that the condition of the walls, even in the sublevel, excites favorable comment from visitors.

Following the general plan of the entire department, most of the furnaces have been placed in batteries and along "flow-line" principles so that the line of travel will be as nearly as possible in a continuous line from the charging end of the first furnace to be used clear through the inspection department and thence out to the machining or assembly departments. It was found impossible to carry out this plan on all work, but the heavy tonnage jobs were taken care of in this way. Thus, the front axles are treated in a battery of three furnaces located in the southeast corner of the building as shown on the floor layout sketch on pages 48 and 49. These are three pusher-type furnaces with automatic push time controls, the first two being gas fired and the last one heated by electric energy. The furnaces are set alongside each other in such manner that the discharge of one furnace takes place on the same end as the charging of the next.

Each of the above furnaces is wide enough to pass sidewise axles for "standard gage" trucks. Miscellaneous axles are taken care of in the largest of a nearby set of five box-type

Electric Furnaces With Rotating Hearth Are Utilized for Normalizing, Hardening or Drawing Miscellaneous Parts of Moderate Size



One of the Double-Chamber CounterflowFurnaces for Carburizing. Boxes are pushed through endwise; two lines in each chamber give four lines in each furnace

gas-fired furnaces used for such odds and ends.

Near the above installation is a similar set of three furnaces for crankshafts. (Two are installed, with floor room reserved for a third when production is such that the high heat furnace cannot do all the heating for both hardening and normalizing.) Still another similar installation handles rear axle shafts. As has been described for the front axle furnaces, these two installations are intended to give a continuous flow of material with a minimum of labor cost and less fatigue of the workmen. Nearly all handling at these batteries is done by means of overhead tracks carrying electric hoists from which hang tongs or slings especially designed to handle the part being treated. At one group a loop track carries the work to the straighteners. All these trolley tracks are shown on the plan.

Rotary Furnaces For Small Parts

Another glance at the floor plan will show a number of furnaces for smaller work. Five rotary furnaces, together with a quenching tank and elevating conveyor attached to each, are especially efficient and economical. Typical work handled includes universal yokes, steering arms, knuckles and carburized gears. Either normalizing, hardening or drawing may be done in these furnaces. The photograph on the opposite page shows some knuckles being hardened. One of the rotaries is of the latest automatic dumping design for handling small pieces. The parts are dumped automatically into the quench and carried up through an inclined rotating perforated drum with internal helical baffle which deposits the work at the end of the tank.

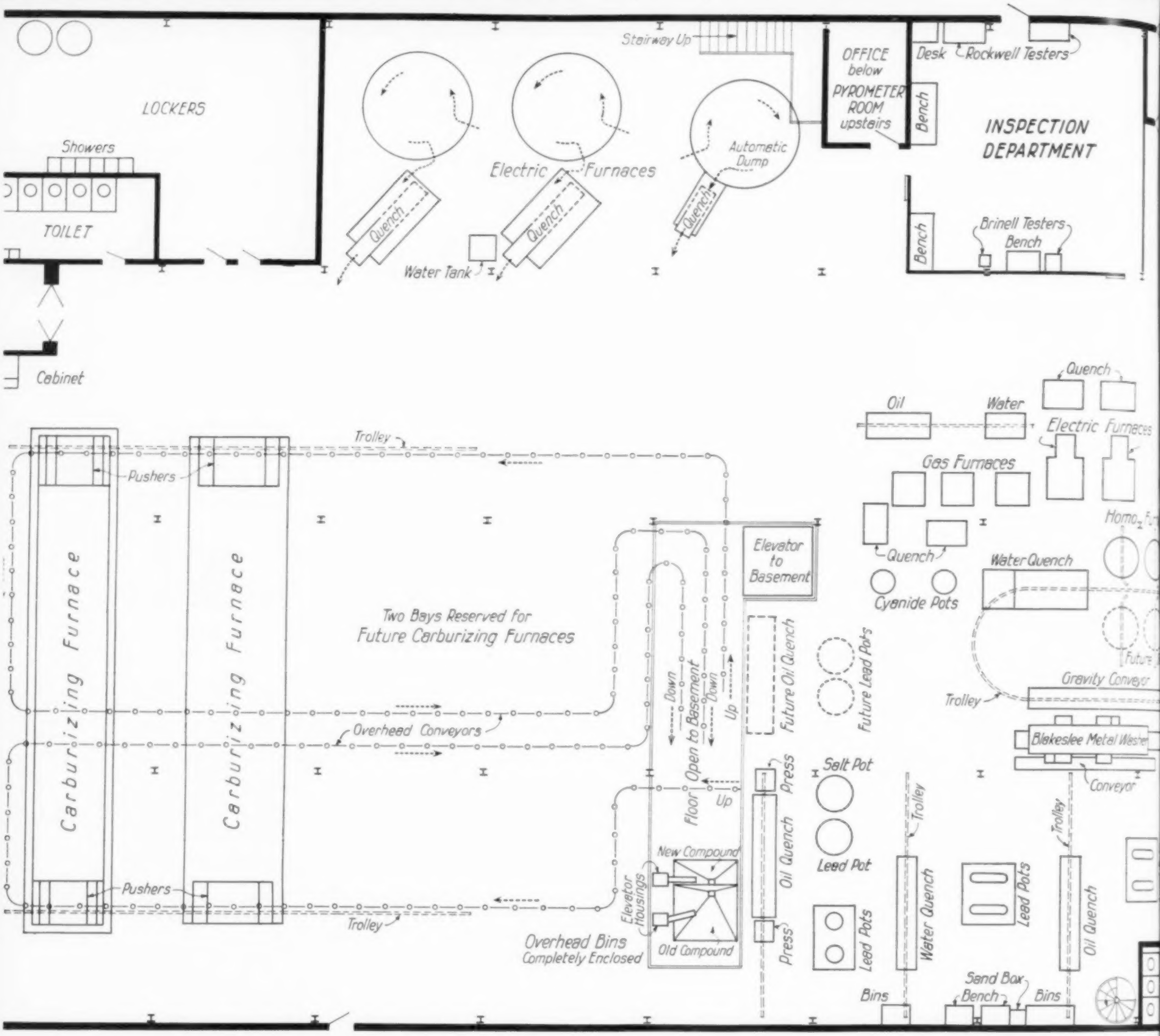
A section approximately 75 ft. square is provided in the center of the department for an assembly of smaller equipment, such as three Homos (eventually six), some lead and salt baths, and the necessary quenching tanks. Drawing baths will eventually be superseded by the Homo furnaces mentioned above.

Six lead pots in three hooded settings are used to harden gears, jack and propeller shafts, and finish machined pieces which must be held to size or have clean surfaces. Four of them have rectangular and two have round pots.

The floor plan also shows two cyanide pots, three small gas box-type furnaces and two small electric furnaces. Camshafts are heated in the last named and quenched in brine by being rotated under three strong streams of the quenching fluid, thus giving a straight and extremely hard product.

Metal washers and rinse tanks clean such parts as need it before or after treatment.

One whole end of the floor is devoted to carburizing. Two double chamber, gas, counter-

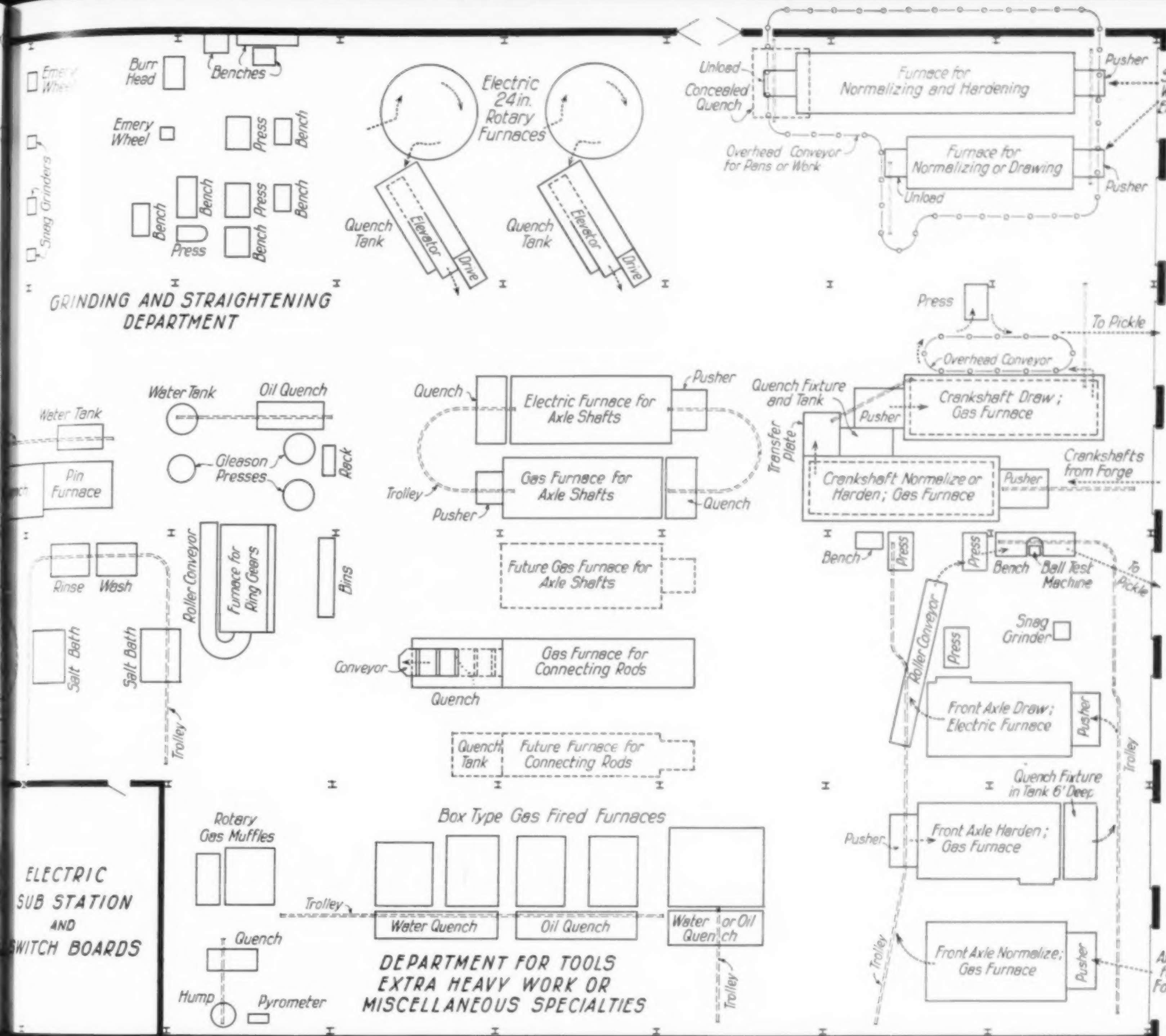


flow furnaces are now in place with room provided for doubling this capacity when necessary. Two lines of pots (one in each direction) are pushed through each of the four chambers mentioned above; each end is both a charging and discharging station for the pots carried to and away from the furnace by the overhead conveyor running from and to the basement.

Work is scheduled so the three standard depths of case ("light," "medium" and "heavy") can be made in the same chamber by setting the pusher timers at the proper interval. All boxes go through the furnace endwise and are of the same width and height, but the length is adapted to the articles contained in the box.

This equipment, accompanied by a simple control system, has developed a product of remarkable uniformity at low cost. A photograph shows the end and side of one of these furnaces together with a workman manipulating a box from the overhead conveyor.

From the above description it will be seen that the furnace equipment is subdivided by functions. In contrast, the pyrometric control is centralized in one room just above the office. In this room are 74 potentiometer recording controllers. (A very few have no recording device.) Each one controls electric relay switches or gas valves to regulate the heat put



into the particular furnace or zone containing the thermocouple. A control operator is constantly on duty. He is always informed of the work being done in each individual furnace, and keeps each one operating at the temperature prescribed by the heat treating specifications. An inner phone system connects him with various parts of the department, and he also has a horn signal for calling various persons on the floor. No signal lights or deviation meters are necessary (except on cyanide and lead pots where the operations are of the short time batch variety); any variation in operating condition is reported immediately to the proper person on the floor and the required changes are carried out. Both meters and recorders are checked at frequent intervals and defects are immediately remedied.

Each gas or electric furnace is metered, and readings are taken every morning and also whenever a new part or operation is begun. Actual cost of heat input is figured and added to the direct labor and overhead. In this way, each job is loaded with the actual cost of heat treating. Furthermore, the operating cost for each furnace is known, whether idling or heating metal. In slack times, such costs enable the superintendent to favor the most efficient furnaces, and to determine whether it is cheaper to shut down a furnace or to idle it for a waiting

Part of the 74 Instruments in the Central Control Room. One operator is responsible for maintaining temperatures in all the furnaces according to the specifications of the work being handled

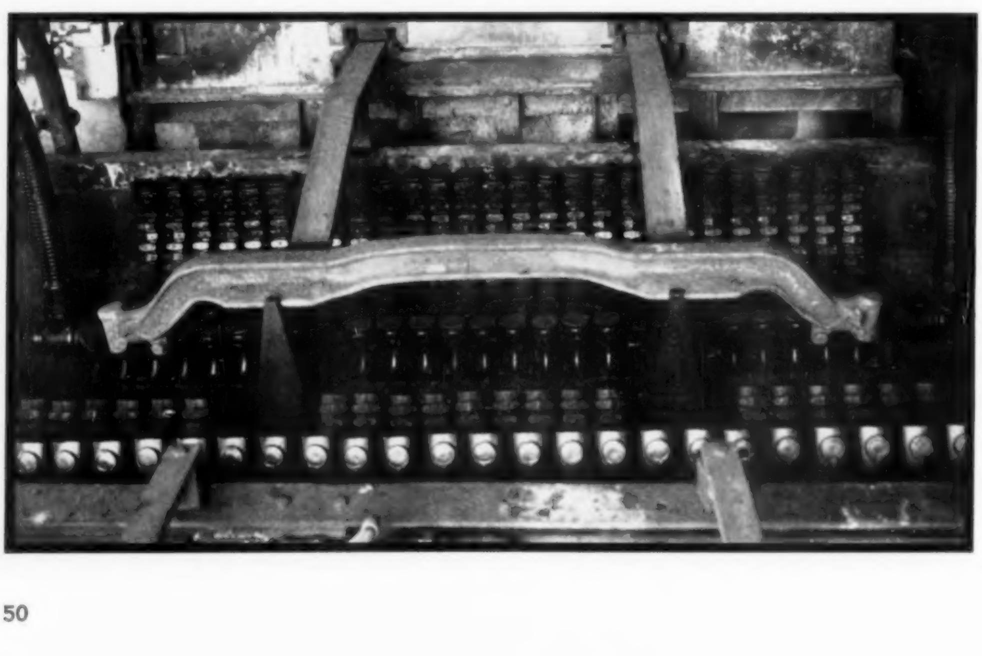
period of known length. Even were there only enough work for a single furnace, it would be operated continuously 24 hr. a day until all the work was finished, it being clearly demonstrated that such a plan is more economical than intermittent work during day shift only. It is also expected that these cost data, together with other data concerning thermal efficiency, design and manner of construction, will be valuable in the selection of future installations.

The smaller plan of the basement on page 51 shows the arrangement of storage and cooling tanks for quenching oil and brine. Water from water quench tanks is circulated to and from a spray pond by a pump; another pump circulates cooling water between spray pond and oil cooler. Nearly all of the quenching tanks are piped for both oil and water; all the piping and conduit in the plant are painted according to the following system: Water, blue; oil, orange; brine, green; compressed air, black; steam, cream; gas, yellow.

A special quenching fixture was developed some time ago for the crankshafts, and the same idea was modified slightly to make the machine adaptable for front axles. The latter are water quenched.

Secure Uniform Hardening

The tank provided measured 4x9 ft. in area by 5½ ft. deep, and was originally furnished with a good supply of running water into which the axles were quenched. It was found that numerous axles had to be retreated because of non-uniform hardening. Since the fixture was installed in the tank, these rejections have been cut down to almost nothing. One test of 48 readings on



A Hot Axle Has Just Slid Out of the Furnace, Into a Quenching Fixture. When submerged, the crescent-shaped castings close in and project jets of water from all directions

a batch of 24 axles showed 47 ball impressions of 3.70 mm. diameter and one measured 3.65.

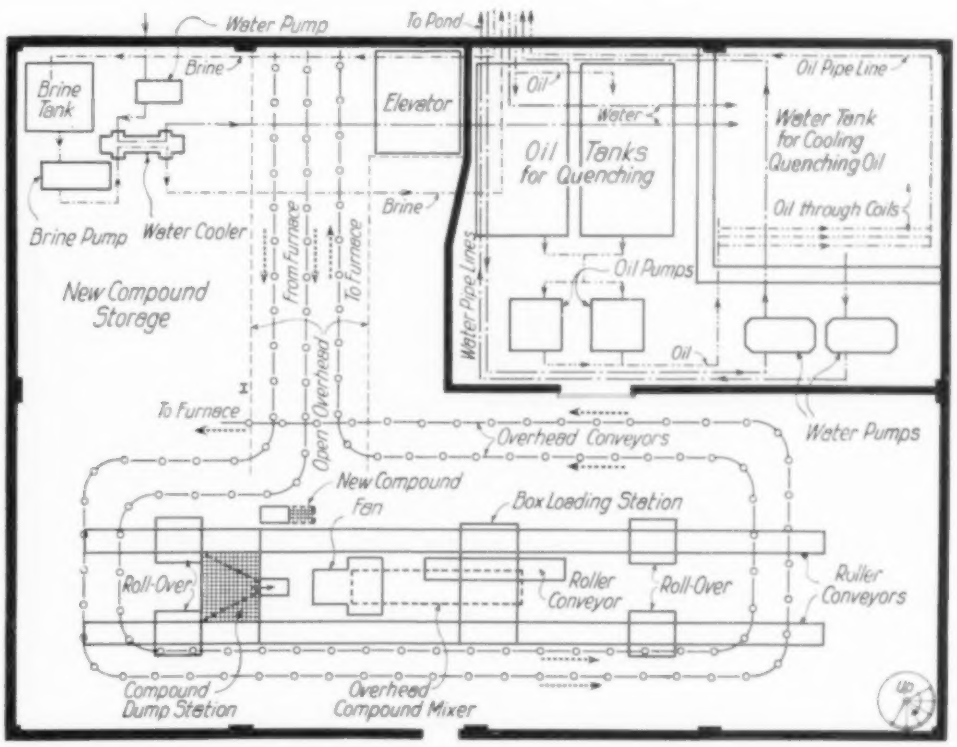
This fixture is shown in the accompanying view. In the open position it is up under the delivery skid from the furnace. In its center are two saddles which catch the hot axle as it slides down and hold it temporarily just above the water's surface. The attendant then turns a control valve and the saddles are depressed; at the same time, a series of crescent shaped castings is closed, entirely surrounding the hot axle by what is, in effect, a perforated drum from which are directed several hundred water jets striking the axle from all directions, thus causing a very drastic water quench. Meanwhile, the entire fixture has submerged itself below the surface of the water, and thus any steam or splash is absorbed. After the axle is effectively quenched, a reverse series of operations brings the axle above water, the spray automatically cuts off, the fixture opens up, and the axle is in position where it can be hooked out easily by overhead hoist and transferred to the drawing furnace.

Water is supplied to the quenching fixture through a pair of pipes (which are, in fact, the pivots about which the machine is closed) supplied in turn through armored hose with water at 45 to 50 lb. pressure from a booster pump. This pressure is sufficient to penetrate the surrounding water and create the proper condition of turbulence at the central zone occupied by the hot forging.

Doubtless, the most unique feature of the Fort Wayne heat treat is the method of handling and reclaiming carburizing compound. This essentially dirty and dusty operation is ordinarily relegated to a separate building, or a walled-off portion of any plant which makes any pretense of cleanliness. Here, however, it is done in a commodious basement connected with the main building by an open areaway in the floor, 10 ft. wide by 60 ft. long. Operations are so well hooded and dust is so well under control that after two years' operations, the walls of this basement are still clean.

The small plan of this basement, studied in conjunction with the main layout, shows how boxes from the furnace arrive, via overhead chain conveyor, at the extreme end of a pair of roller conveyors. Since the boxes and contents ride on the covers, they are first rolled over and then dumped on a screen, closely hooded, and exhausted by duct to a large fan and thence outside to a cyclone separator.

It takes about five hours for the boxes to traverse the distance from furnace to shakeout, so the boxes are relatively cool, although at the center the compound may be somewhat warm. Falling through the screen it slides into an elevator boot and is immediately taken up and delivered through the top of a tightly closed bin in the roof of the main building. A companion elevator feeds new compound into



Carburizing Loading, Unloading, and Storage Are Done in the Basement. Pumps and other equipment for handling quenching solutions are also housed there

a smaller compartment of that same overhead storage bin.

This bin is equipped with a steam line to smother any fire which might occur in the hot compound. It is so regulated that the hot compound stays in the bin but a very short time. When the plant shuts down, the bin is entirely emptied into sheet metal skids to be returned, when the need again arises, to the storage bin above.

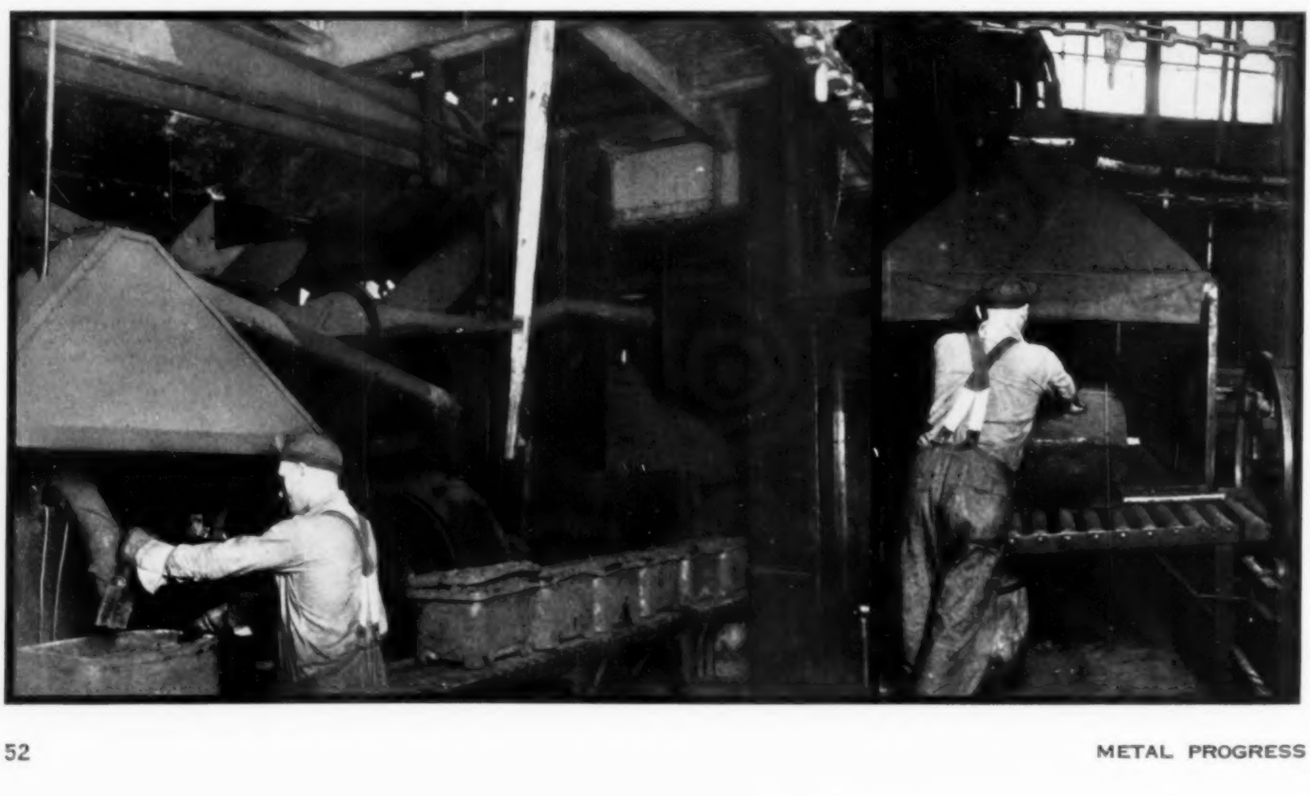
Old compound and new compound are drawn from this bin at determined rates. Each section discharges on a pan feeder, driven at correct rate by variable speed pulleys. In this way any mixture desired of old and new can be delivered to the mixing drum. All this equipment is entirely enclosed and dust is exhausted to the outside cyclone catcher.

The compound mixer is a long, rotating cylinder, diameter about 30 in., set at a slight angle, and rotating within a tight housing. For two-thirds its length the compound, new and old, is slowly mixed as it gradually works its way by gravity toward the lower end. For the last third the cylinder is perforated so that fines are effectively screened out and vanish via the fan and dust catcher. Coming out at the end, the properly mixed compound is run into a bin having spouts leading to either of two closely hooded loading stations, where carburizing boxes are packed with metal and compound. Loaded boxes are rolled over, hooked to the chain conveyor by special tongs, and are carried automatically to the furnace end.

The arrangement of this part of the department is clearly shown by the photograph below. It was devised by International Harvester Co. employees in conjunction with a conveyor manufacturing company which built the equipment. It has proved eminently satisfactory in all respects, since it has converted an operation which is undesirable and inefficient into one which can be performed by a self respecting workman; and self respecting workmen build a better product.

Metallurgical quality is an unmeasurable thing in the sense that it cannot be determined with a yardstick or a micrometer caliper, but its importance cannot fail to be recognized. All the above described equipment has been installed after much planning and study and at considerable capital outlay so that good metal might be heat treated as perfectly as is commercially possible. The result aimed at has been achieved: A truck having better metallurgical quality, and at lower cost.

Loading and Unloading Stations in Carburizing Department. At right of the large picture are the elevator housings carrying old and new compound to the upper storage bin



ZINC DIE CASTINGS

al : cu : mg

4 : 3 : 0.1%

by W. M. Peirce
New Jersey Zinc Co.
Palmerton, Pa.

and Marc Stern
A C Spark Plug Co.
Flint, Mich.

DIE CASTINGS offer certain distinct economies. For example, a large saving in machining cost is possible where a large number of parts of the same design is required. Again, parts of intricate ornamental design may be produced at low cost. At other times, several parts may be combined in one die-cast unit, thus reducing assembly costs. When desired, die castings may be plated.

Of the various metals suitable for pressure die castings, zinc has the advantage of low cost per pound of metal. Furthermore, because of the low melting point of zinc, dies made of plain carbon steel will have a long life, and it is not necessary to give the dies special heat treatments to resist higher temperatures.

The following established uses give a general idea of the wide range of suitable applications: In the automotive field, die castings made from zinc alloys are used for body hardware, carburetors, fuel pumps, radiator caps and ornaments, speedometer frames and taxi-meter housings and parts. Die-cast gears for many uses, including washing machine and electric hoist gears, have proven successful. Further examples are: Refrigerator hardware, door checks and other interior hardware in the building field; small motor frames, radio chassis and parts in the electrical industry; various housings or brackets in mechanical devices, such as typewriter frames.

Design. The maximum size of commercial zinc-base die castings has not yet been reached. Typewriter frames and radio chassis are fair examples of large castings, while a die-cast cowl bar weighing 14 lb. and with an over-all length of 41 in. represents an extreme.

The accuracy of dimensions ordinarily attained is plus or minus 0.002 in. per inch of length or fraction thereof up to three inches, and plus or minus 0.001 in. per inch for each additional inch. Dimensions intercepted by the parting line of the die will show a greater variation, but proper die design will usually place the parting line where it will not intercept important dimensions. A draft of 0.002 in. per inch on cores is the minimum desirable allowance.

Proper design of a part for economical die construction and maintenance, for minimum metal, casting,

Prepared for the Non-Ferrous Data Sheet Committee of the Institute of Metals Division of the A.I.M.E. and the Recommended Practice Committee of the A.S.S.T.

cleaning, and machining cost, as well as for maximum strength, accuracy, and perfection of finish, is a problem requiring the services of an engineer skilled in the die casting art.

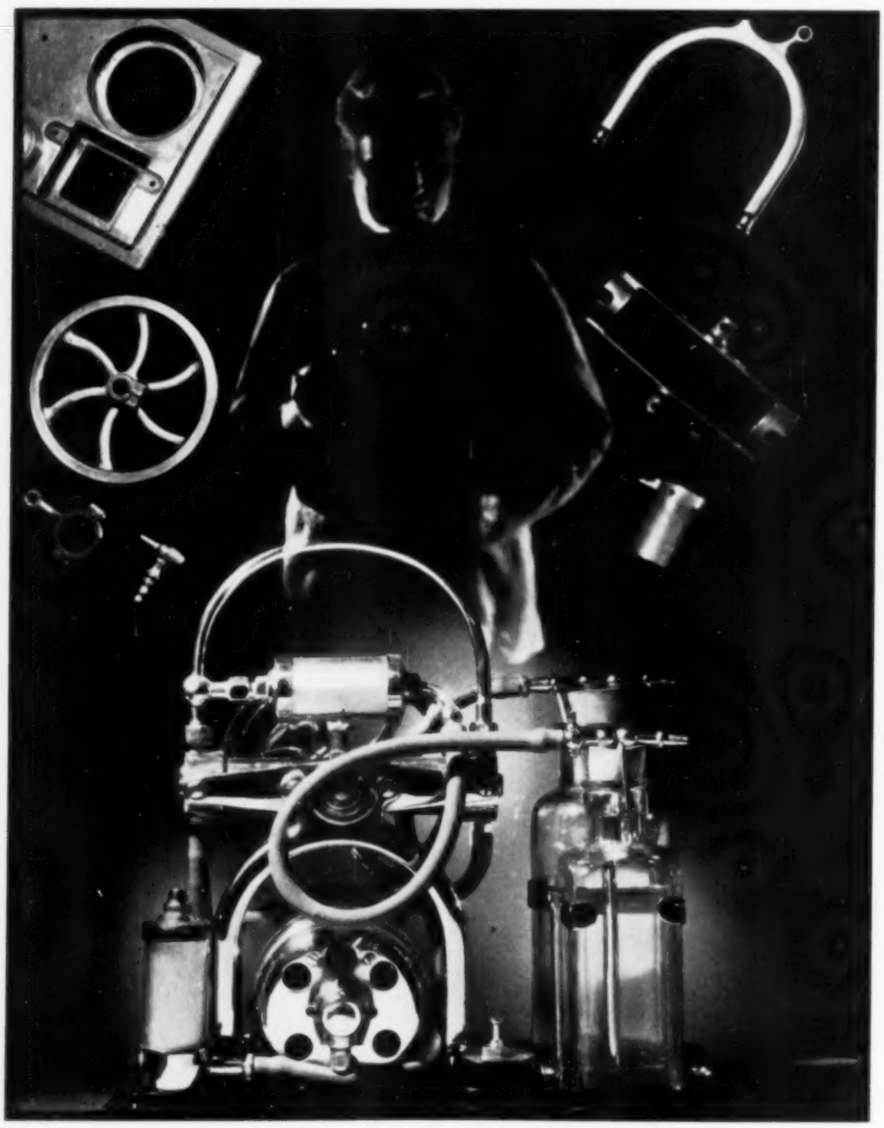
Best Alloy in Use

While numbers of zinc alloys have been employed at various times, the present tendency is toward simplification to a single group. Alloys of this group contain 4% to 5% aluminum, and copper up to 3%. They cast well, and have been widely and successfully used.

Aluminum makes the zinc suitable for the die casting process itself by preventing attack on the die casting machine and die and by increasing fluidity. In addition, the aluminum refines the grain and greatly increases tensile and impact strength. Copper is added up to 3% to increase the strength further. It is also one of the elements which corrects a tendency toward intercrystalline oxidation which exists in the plain aluminum-zinc alloy. A very pure grade of zinc is also essential if such oxidation is to be avoided.

Another element which counteracts the tendency toward intercrystalline oxidation is magnesium, and further improvement (resulting in the complete resistance to any intercrytalline oxidation) has been effected by the addition of this element to the aluminum-copper-zinc alloy. The resulting alloy is patented. One-tenth per cent of magnesium has been widely used. By proper limitation of the impurities in the zinc, especially lead and tin, complete protection may be obtained with 0.02% magnesium. The lower magnesium content eliminates some deficiency in casting properties which is found in the alloy containing 0.1% magnesium.

Courtesy New Jersey Zinc Co.



Physical properties of such an alloy are given in this article and are believed to represent the basic properties of the best alloy generally known at present. It has been extensively studied as "Alloy XXI" by a committee of the American Society for Testing Materials and is covered by its tentative specification designated B 86 — 31 T.

Chemical Composition

Composition should be 4.0% aluminum plus or minus 0.5%; 3.0% copper plus or minus 0.50%, and 0.02 to 0.12% magnesium; balance is zinc containing 0.02% maximum impurities. The castings must contain less than 0.01% Pb, 0.005% Cd, 0.10% Fe, 0.005% Sn, and less than 0.02% of all other impurities.

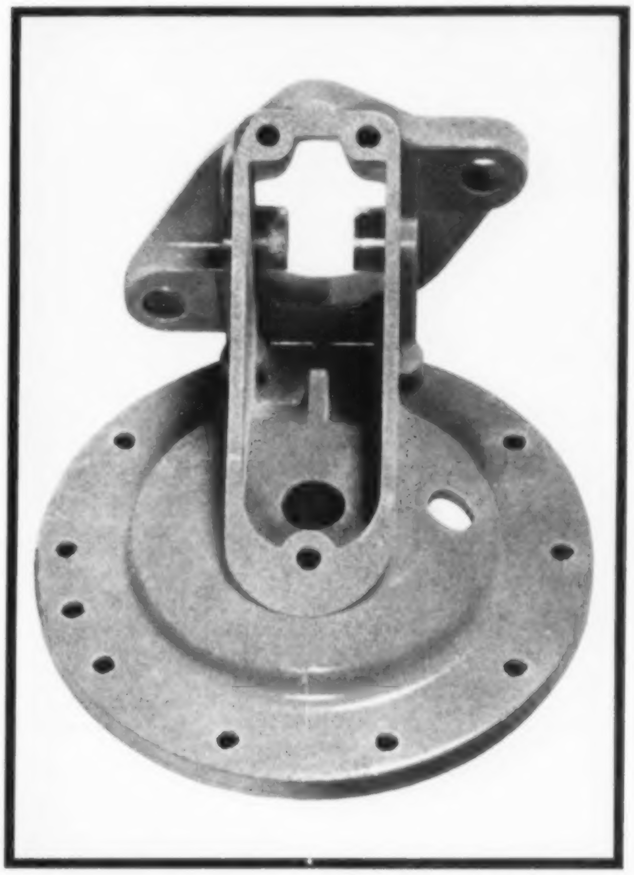
It is generally realized that the physical properties of a cast metal are dependent in a large degree on the casting conditions and the design of the casting. This is particularly true of die castings; here there is an opportunity for a wide variation in the amount of chill due to the design, cooling, and operating temperature of the die.

The zinc alloy described above is affected by such conditions. For example, the tensile strength may be increased by unusual chilling, or lowered by casting in an unusually hot die. Impact strength, on the other hand, will vary inversely as the tensile strength, low tensile being accompanied by a high impact value, and vice versa.

Die castings are usually of such size and shape that test specimens cannot be machined from actual die-cast parts. A standard die for casting tensile and impact specimens has, therefore, been included in the above-mentioned specification. Tensile specimens widely adopted are of two types — a flat bar 1/8 in. thick with a 1/2-in. reduced section representative of a light wall, and a round specimen with a 1/4-in. reduced section 2 1/4 in. long. The latter is specified in B 86 — 31 T, and is representative of a somewhat heavier wall section in actual casting. A 1/4x1/4-in. Charpy impact specimen is also specified.

Physical properties noted below and in the table are based on specimens cast in such a die under average conditions. To make all the data comparable, all specimens were cast from one melt. The original properties, however, approximate very closely the average of many independent determinations. It must be recognized that various sections of commercial castings may differ considerably from these figures due to differences in chill and metal flow.

All aluminum-zinc alloys undergo a phase change after freezing which is accompanied by a slight shrinkage (beta phase to alpha plus gamma phases at about 520° F.). The chill produced by the steel dies causes a partial or complete arrest of this change, but it will rapidly complete itself in use under conditions involving mildly elevated temperatures — for instance, 212° F. Physical properties after aging in a dry atmosphere at 203° F. are, therefore, included in the table.

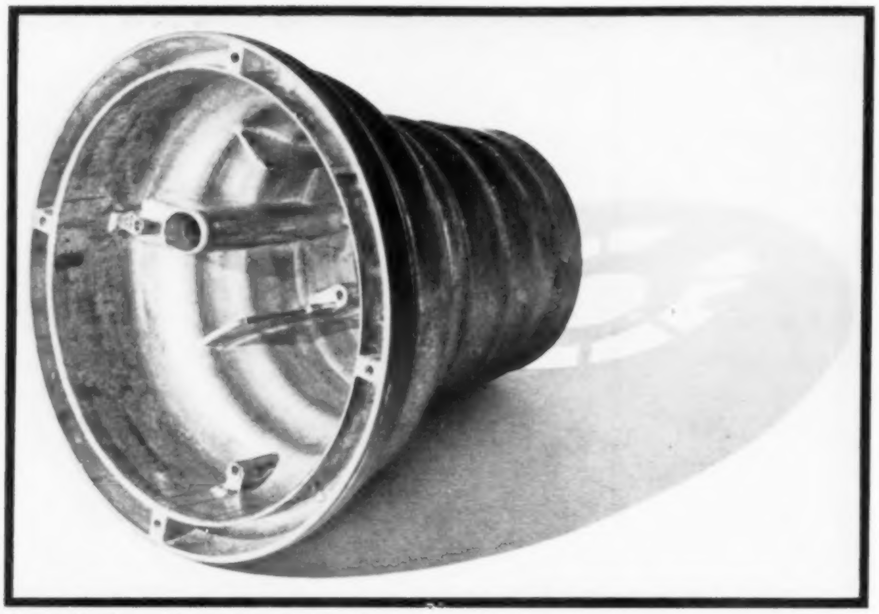


Courtesy A C Spark Plug Co.

Since certain uses involve exposure to conditions of high humidity and temperature, the tensile and impact properties after exposure to atmospheres saturated with water vapor at 203° F. are also tabulated. The change in properties occurring during such a test is obviously

EFFECT OF AGING ON ZINC-BASE DIE-CAST ALLOY

	As Cast	Aged in Moist Air at 203° F.		Dry Anneal 203° F. 20 Days	Indoor Aging 2 Years
		2 Days	20 Days		
Tensile Strength					
1/8-in. flat	47,800	44,400	36,400	37,100	53,700
1/4-in. round	47,300	44,300	39,000	40,200	51,100
Impact Strength (ft-lb.)					
1/4-in. square	8.0	4.75	0.94	1.25	3.75
Dimensional Change					
Inches in 3/4-in. section		minus 0.0001	plus 0.0027	plus 0.0016	minus 0.0004
Brinell Hardness	88	–	–	69	87



The Following Photographs by Courtesy of New Jersey Zinc Co.

a combination of the effect of aging at elevated temperature and surface corrosion due to moist air at elevated temperature. This test originated as an accelerated test for some of the early zinc-base alloys which were subject to severe intercrystalline oxidation. The periods of test used are equivalent in effect to a great many years of exposure to tropical atmospheres, and to much longer periods of exposure in temperate climates.

The tests given in the table were made on castings from a single experimental run of the zinc-aluminum-copper-magnesium alloy described above. The results check numerous similar experiments, and are known to be typical of good commercial practice. It would be a mistake to construe the values given as the minimum, or necessarily as the average to be expected commercially. For instance, the difference between the original tensile strength of flat and of round test bars is so small that on different melts of the same alloy the reverse order of superiority may occur.

Minimum results to be expected from test bars cast during the manufacture of zinc-base die castings of this analysis are contained in the A.S.T.M. specification B 86 - 31 T, as follows:

Tensile strength of $\frac{1}{4}$-in. round test bars; minimum average of five specimens, 44,000 lb. per sq.in.; minimum for individual specimen, 35,000 lb. per sq.in.

Elongation in 2 in.; minimum average of five specimens, 2.0%; minimum for individual specimen, 0.5%.

Charpy impact; minimum average of five specimens, 6.0 ft-lb.; minimum for individual specimen, 4.0 ft-lb.

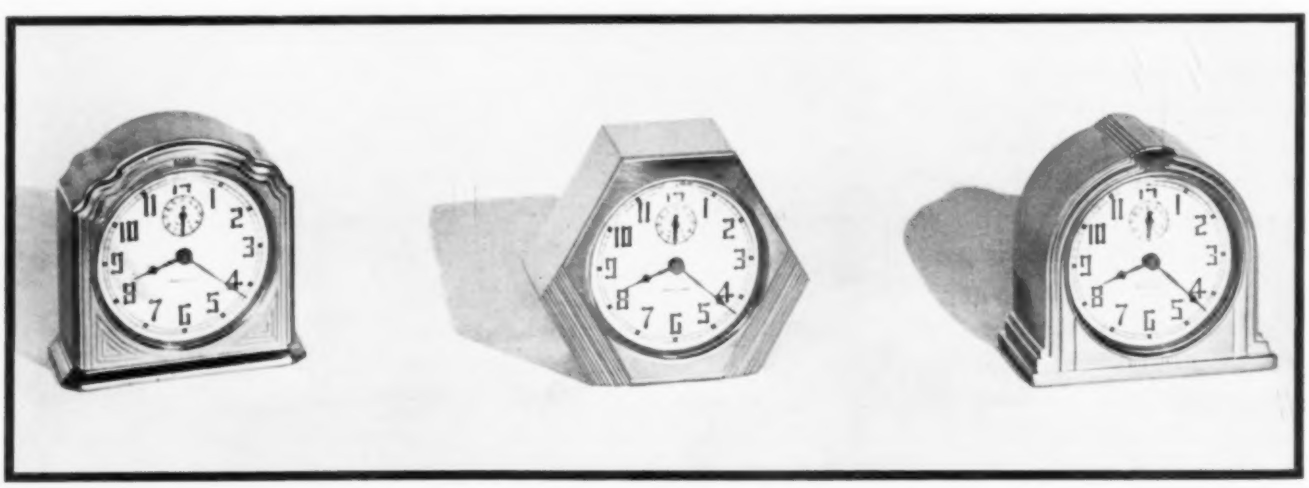
Other physical properties (average values) for this die-cast alloy are as follows:

Specific gravity, 6.8.

Melting point, 741° F. (393° C.).

Shrinkage allowed for casting, $\frac{1}{8}$ in. per ft.

Approximate compressive strength, 90,000 lb. per sq.in.



Brinell hardness number, using 10-mm. ball with 500-kg. load for 30 sec., 75 to 100. It should be remembered that Brinell or Rockwell hardness tests on die castings are generally considered unreliable.

Rockwell hardness (red figures on E scale), 85 to 100. (The "E scale" refers to a $\frac{1}{8}$-in. ball penetrator with 100-kg. load, taken from the red figure scale on the dial.)

Specific thermal conductivity for the range between 25 and 100° C., 0.253 calories per cubic centimeter per degree Centigrade.

Thermal expansion, per unit length, for the range between 25 and 100° C., 0.0000295 per degree Centigrade, or 0.0000164 per degree Fahrenheit.

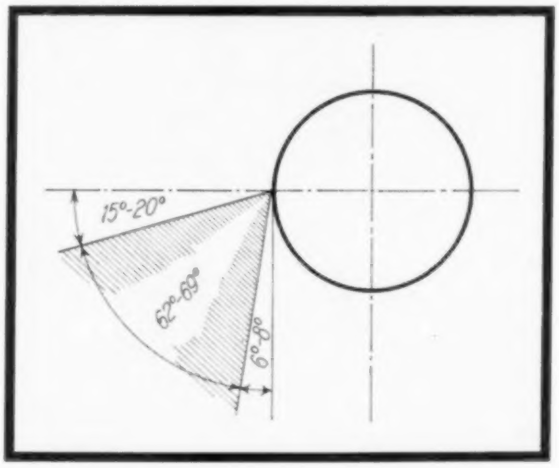
Electrical conductivity at 20° C., 136,300 mhos per cubic centimeter.

Electrical resistance at 20° C., 0.000007338 ohms per cubic centimeter. Temperature coefficient for the range between 20 and 100° C. is plus 0.003030 per degree Centigrade; that is, the resistance at an elevated temperature t equals the resistance at 20° C. plus a quantity found by multiplying the resistance at 20° C. by the temperature coefficient by the difference between t° and 20°.

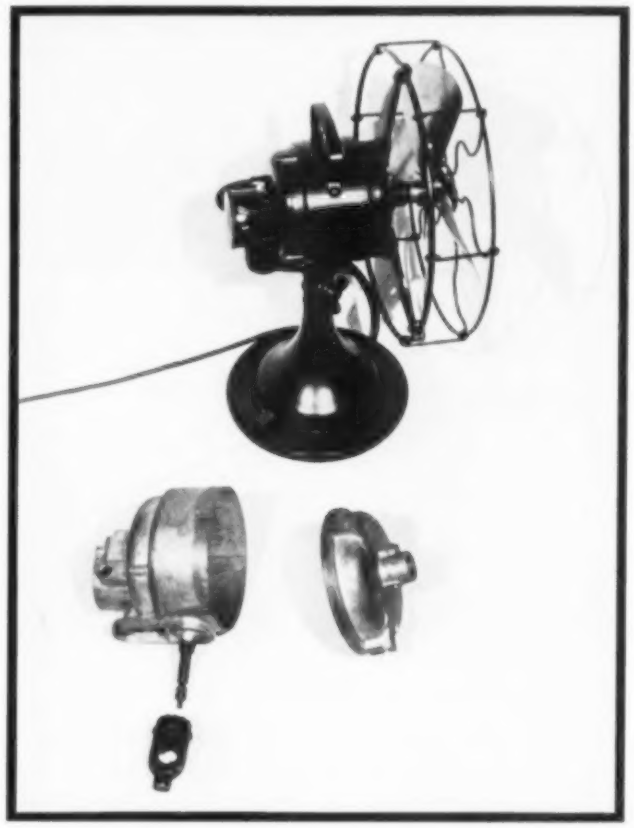
Machining Properties

Machining. A primary requirement for machine work is the maintenance of a keen, smooth cutting edge on the tool. High speed steels are usually satisfactory, but for exacting dimensional requirements, special cutting tools such as tungsten carbide are very effective. Cutting angles are shown on the adjoining sketch.

Cutting Angles Recommended for Zinc Die Castings



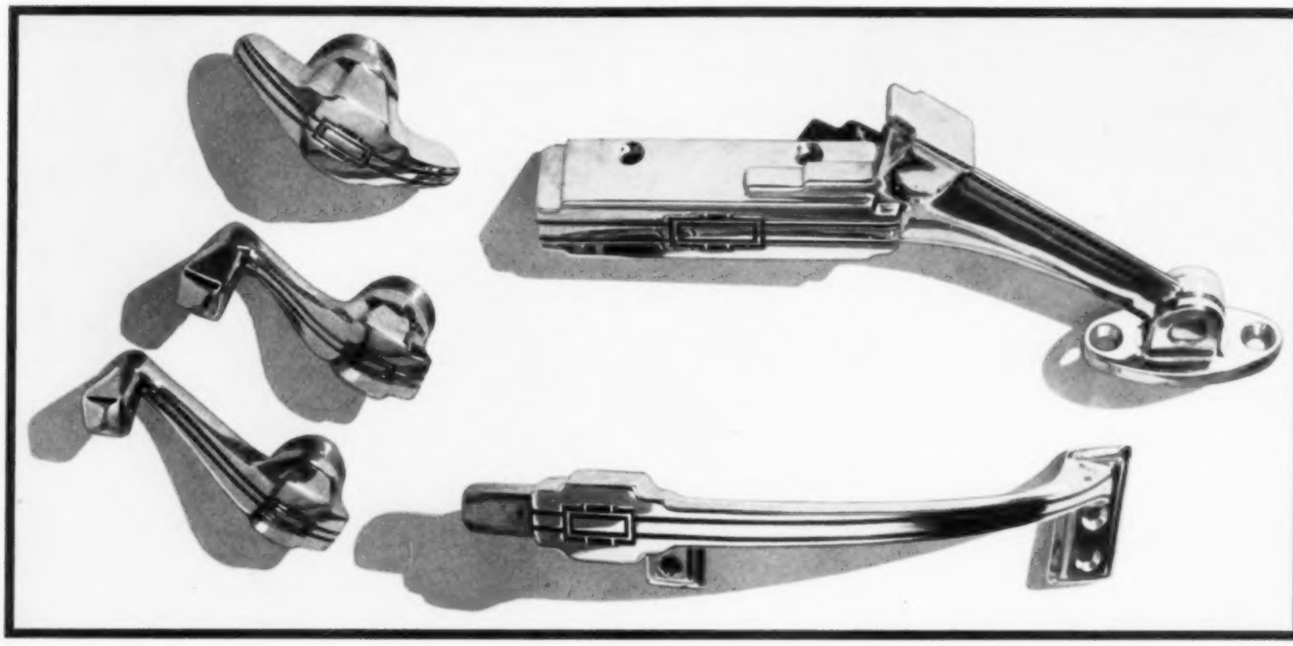
Milling cutters, end mills, reamers, and similar tools produce the best results when they are of coarse-tooth spiral or helical design with an appreciable top and side rake. Two-fluted spiral taps with ground and relieved threads providing ample chip clearance and rapid chip removal have been found satisfactory. Crowding of taps can be avoided if the holes are cast slightly larger than the usual standard practice.



Drilling Recommendations

The same principle applies to drills. Two-fluted drills, having spiral angles about double the usual 24°, are satisfactory. The included angle of the cutting edges may be advantageously reduced. Clearance angle may be increased to 15° at the periphery of the drill and gradually increased still further as the drill point is approached. Beveling off the end of the flute back of each cutting edge provides more chip clearance for rapid work.

Zinc-base die castings are electroplated fre-



quently. The degree of protection which can be obtained by plating against various conditions of exposure is dependent upon the quality and weight of plating, as is true of other metals. Nickel is generally accepted as the most satisfactory first coat, since it has no tendency to absorb or diffuse into the base metal. It is best deposited from a high sulphate bath such as the following:

Single nickel salts (nickel sulphate)	10 oz. per gal.
Anhydrous sodium sulphate	15 oz. per gal.
Ammonium chloride	1¾ oz. per gal.
Boric acid	2 oz. per gal.

If hydrous sodium sulphate is used, 30 oz. per gal. is necessary. Room temperature is correct for operating, and current density should be 8 to 20 amp. per sq.ft.

Preparation of castings by grinding and buffing does not present any unusual problems. It is best to avoid deep grinding; it may cut through the dense surface layer which offers the best surface for plating.

The following cleaning solution is satisfactory; one minute at 175° F. is usually sufficient; if necessary, it may be used very effectively as an electro-cleaner. Crystallized trisodium phosphate ($Na_3PO_4 . 12\ H_2O$), 6 oz. per gal., and caustic soda ($NaOH$), 1 oz. per gal.

Lacquers may be effectively used, and baked finishes may be applied at baking temperatures up to 450° F. Finishes involving such heating are not recommended for parts requiring close sliding fits. Any air trapped near the sliding surface will expand at temperatures above 400° F. and raise blisters which interfere with the function of the part. A decrease in ductility and impact strength is also likely to result from this condition.

AUTOMATIC POLISHING

of metal specimens

by R. G. Guthrie
and J. A. Comstock
Consulting Metallurgists
Chicago

EVER since the microscope was adapted to the study of iron and steel, metallographists have been continually improving their methods for preparing the sample. These methods of preparing a metallographic specimen involve several stages or steps, the eventual purpose of which is to obtain gradually an optically flat surface, free from scratches or marks, in the shortest practicable time and with as little effort as possible. Inasmuch as there has never been devised any standard or universal method for this purpose, improvements in technique have come, for the most part, by improving one or another stage of the methods in vogue at the time. As a result, many metallographists use one type of method for certain stages of preparation, and another type of method for another stage.

The first phase of the problem to receive close attention had to do with the polishing surfaces or cloths and the abrasives used thereon. Consideration was given to all manner of grinding and polishing powders and a great many varieties of fabrics and other backing-up material for use both wet and dry. Recently, there has been a growing tendency to adopt a few abrasives and polishing powders and to accept a few fabrics and other surfaces as being adaptable for the ordinary metals and alloys, and to devote more attention to new machines and labor-saving apparatus for use in the preparation of specimens.

During the earlier uses of the metallographic microscope, great and tedious care was taken to prepare a sample suitably, and an almost endless number of rules was laid down by various authorities as to the best methods of doing this. Not so long ago, it was thought by some metallographists that a surface prepared in less than an hour by any but the most laborious methods was unsuitable for examination under the microscope. More recently, however, it has become possible to obtain preparations of a quality beyond any produced by older methods with very much less individual effort and in a considerably reduced time, principally by the use of new apparatus developed for this purpose.

The problem of automatic polishing has been attacked in two ways; namely, by constructing magnetic specimen holders and mechanical specimen holders. Both devices, in

Macrograph of Cross-Section of Brass Ingot. Etched with ammoniacal hydrogen peroxide. Magnification 3 times; original view 6½ in. high

their original form, had certain disadvantages, as could be expected; the magnetic specimen holder, however, now seems to be superior to mechanical devices, principally because it permits the specimen to be removed instantaneously at any stage of the grinding and polishing procedure, and also because the magnetic pull reinforcing gravity and coming from below the disk gives better and flatter surfaces than when the sample is held by mechanical pressure exerted from above.

The authors have been working for a long time on all of these phases with increasingly better results, and have improved and changed their original methods not less than a half-dozen times in the last five years. The methods and apparatus outlined in this article represent the contemporary state of the situation in our laboratory, and have superseded all the others formerly used. Our success may be measured by the statement that, whereas it formerly took the entire attention of one well-trained man one hour to prepare a typical specimen, the same man can now prepare ten specimens in one hour.

This fact, although significant, is not nearly so important as the fact that the samples prepared by the new method are of infinitely better quality in every respect than the best sample that could be prepared by the older methods! Furthermore, these ten samples, if of the same class of material, will have surfaces which are duplicates of each other, capable of the finest comparisons, whereas this degree of reproducibility cannot even be approached by the methods used in the past.

Aside from the production of an optically plane surface, free from marks or scratches, there is a deeper, more important consideration to be taken into account in the preparation of metallographic specimens. We refer to the ability of the sample to become the subject of a finished photomicrograph, which is truly the proof of the quality of the previous work.

It is a fact that almost any microscope is capable of much finer work than has been done with it by the metallographist, simply because many technicians presume that the preparation of the sample is a distinctly secondary consideration and that the prime consideration for

good photomicrography is the actual manipulation of the microscope. As a matter of fact, the reverse condition is nearly always true. Given the best metallographic equipment obtainable and a poorly prepared sample, the most skillful manipulation of the metallographic equipment can only produce a mediocre and unimportant photomicrograph, lacking in detail and contrast.

It was formerly believed that detail had to be sacrificed in the interest of contrast, and vice versa. Frequently, certain micro-constituents could not be studied because they could not be resolved, and this in turn was simply because the preparation had been faulty. It is now possible to study the same micro-constituents and their true proximities.

The method of sample preparation used by the writers in producing the accompanying photomicrographs is suitable for practically any metal or alloy, from the softest to the hardest and most brittle. A brief series of notes on the technique now follows.

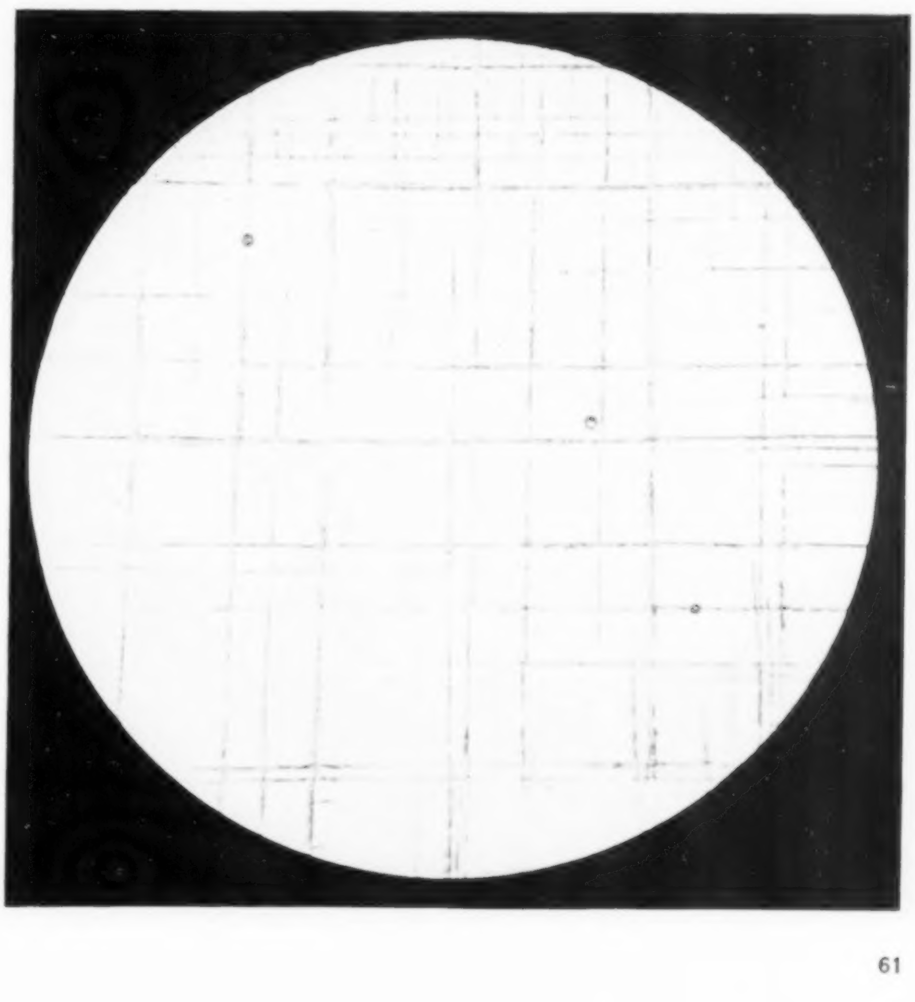
The surface to be examined is cut on a high-speed flexible cut-off wheel. It is then practically flat, and therefore requires only the minimum amount of fine grinding previous to the polishing operations.

Rough grinding is performed on a bench grinder having one horizontal spindle carrying two vertical, dry wheels operating at about 3600 r.p.m. Most materials require nothing more than touching up on a 100-mesh carborundum wheel, operated dry.

Fine grinding then follows on a special two-spindle automatic polishing machine, designed by one of the writers and equipped with magnetic specimen holders. Polishing disks are removable. One of them is prepared for fine grinding by coating it with a layer of molten paraffin about 3/16 in. thick and allowing the paraffin to solidify. The next step in making up the disk is to cut radial V-shaped grooves about 1/16 in. deep in the surface of the paraffin; spacing is about 1/4 in. apart at the periphery. (The purpose of these grooves is to carry the lubricant and abrasive under the sample in the same manner as oil rings function in a bearing.) The abrasive used is 180-mesh carborundum grain. It is applied to the surface of the paraffin disk in a mixture of 50-50 liquid soap and water, using an ordinary paint brush.

This disk should be operated at about 1500 r.p.m. One or two minutes is sufficient to remove all previous abrasions and produce a finely ground surface suitable for polishing.

Coarse Polishing. The first actual polishing operation, as carried out on this special automatic polishing machine, requires a disk cov-

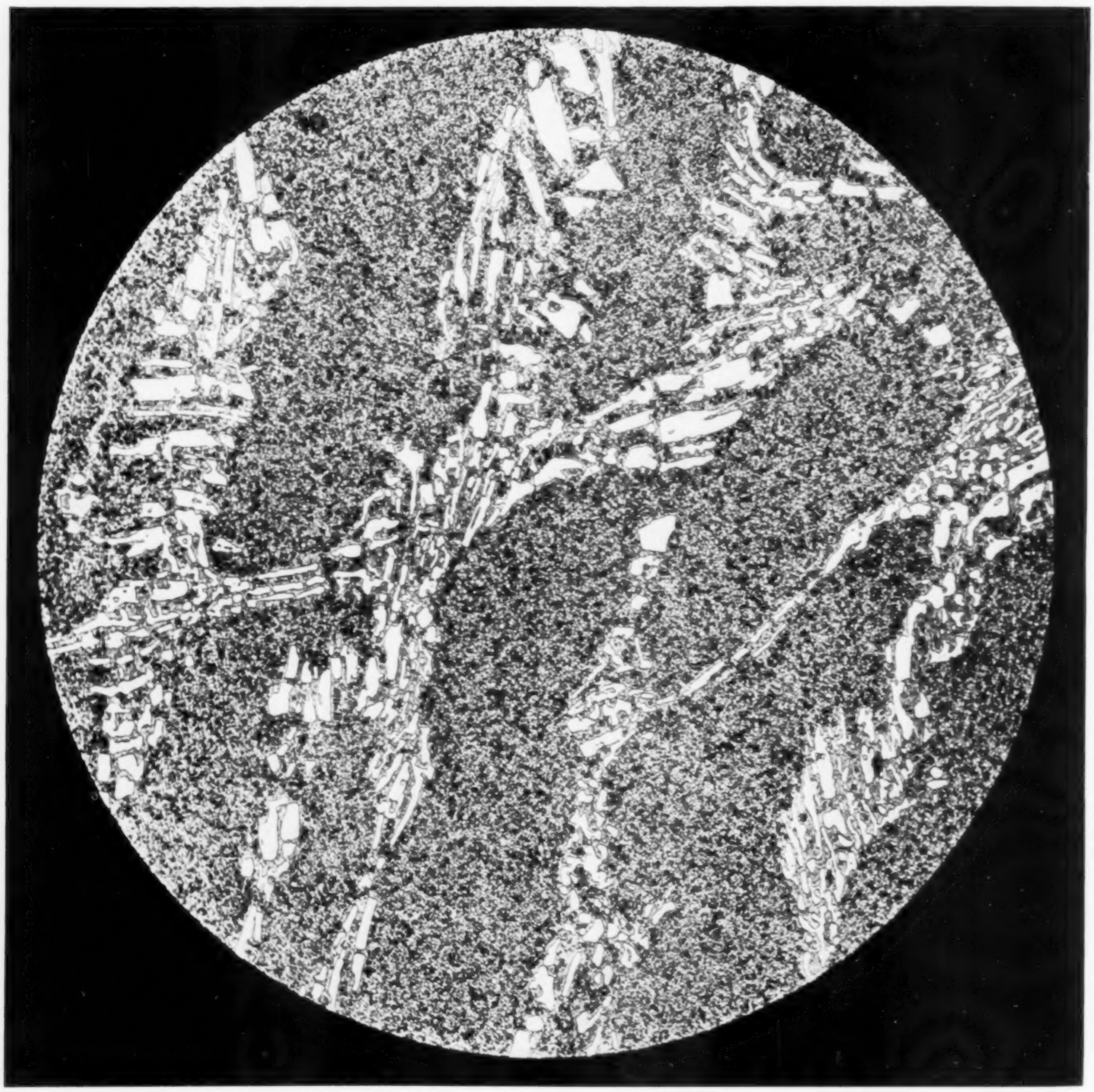


Portion of One Grain of Austenite in Annealed 12% Manganese Steel, Showing Slip Lines Among Crystallographic Planes. Etched with saturated picral. Magnification 400 times; original view 6½ in. diameter

ered with fine broadcloth or French flannel. For polishing powder we use levigated alumina in a 50-50 liquid soap and water mixture. This polishing solution is allowed to drip on the cloth-covered disk. The latter is operated at from 500 to 1500 r.p.m., depending upon the nature of the material being polished. From two to five minutes is sufficient to remove the abrasion from the previous fine grinding operation and produce a brilliant, polished surface which, however, still retains very fine scratches produced by the hard alumina abrasive.

Fine Polishing. Fine polishing is the last stage, and is done on another disk covered with fine broadcloth or French flannel and operated at from 500 to 1500 r.p.m. (according to the nature of the material being polished). Polishing powder is Merck's "Reagent Magnesium Oxide" free from sulphates, made up into a solution with 50-50 liquid soap and water, and

High Carbon, High Chromium Steel Containing Dendritic Segregations of Carbide. Etched with 0.5% nital. Magnification 150 times; reproduced as photographed. Note fine dispersion of small carbide particles throughout ground mass



allowed to drip on the rotating disk. Two or three minutes will remove the fine scratches from the previous coarse polishing operation and produce a highly lustrous surface capable of reflecting the maximum amount of light (which results in maximum contrast in the photomicrograph).

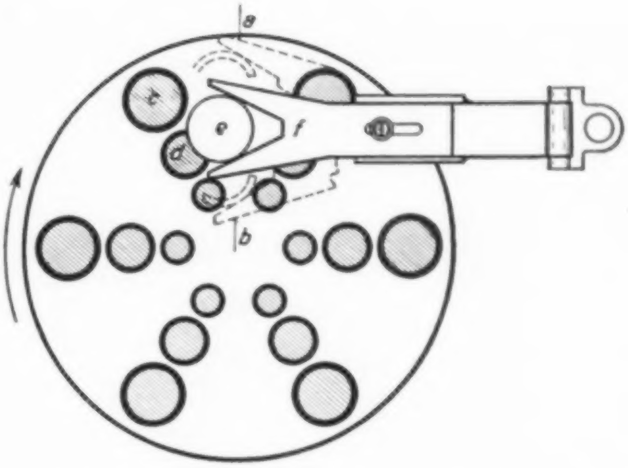
Fresh magnesium oxide has practically the same mineralogical hardness as ferrite, so that iron or steel specimens may be prepared with it having no trace of scratches.

Due to the nature of the polishing powder used in this operation, it is necessary either to change to a fresh cloth covering at least once a day, or to treat the used cloth-covered disk with a dilute hydrochloric acid solution. This will remove the crystalline magnesium carbonate formed by the reaction between the magnesium oxide and the CO_2 in the water.

The feature of this method of preparation is the use of a lubricant on all the disk operations. On trial, it will be readily noticed that the soap solution gives a much quicker and better polish than the use of plain water and abrasives.

On examining a specimen prepared by this method, it will at once be apparent that there are no "comet-tails" or wiped-out inclusions, nor are the hard constituents brought into excessive relief during the normal time required to finish a specimen. Furthermore, it will be noted that specimens require much less time in the etchant. Only a very slight amorphous surface has been formed, and it takes but a little time to remove this with the etching reagent, whereupon the crystalline structure is revealed. This shorter etching time contributes greatly to the evenness of the etch; the microstructure revealed is more nearly true in its tones and shadings than that produced by a deeper and more uneven etch.

After the specimen has once been flattened out by hand on the bench grinder, its preparation thence forward in our laboratory is entirely automatic except for changing from disk to disk. It is not necessary or desirable to do the fine grinding and polishing by hand, since our polishing machine is equipped with automatic magnetic sample holders. These holders exert a uniform and constant pressure, thus eliminating an important personal variable in all hand



Nickel Inserts c and d in Brass Polishing Disk Cause Specimen e to Rotate in Magnetic Holder as Arm f Oscillates Between Positions a and b

methods. Furthermore, these magnetic holders automatically align the sample in the holder, so that no matter how often the sample is removed and replaced it will re-align itself in such a manner that the polishing is always in the same plane. Formation of extra facets and rounded edges is therefore avoided. This feature is highly important when preparing thin sections as well as cross-sections of material to be examined at the edge.

During the last two years, following the introduction of the magnetic sample holders, systematic experiments have resulted in a more critical determination of the best conditions for automatic polishing. These improvements can be summarized as follows:

(a) Increase in the magnetic pull,

(b) Combination of oscillatory and rotary motion of the specimen,

(c) Better bearings for polishing disks.

An accompanying sketch shows a plan view of a brass polishing disk with circular inserts of nickel, which not only increase the magnetic pull on the sample, but cause a sample to rotate within the oscillating holder arm. This device has been added to our all-metal, two-spindle machine with individual motor drives, variable speed pulleys, individual receptacles and covers, and with bearings and lubricating system planned for long life and smooth running.

The standardized conditions obtainable with such an apparatus have solved the problem of obtaining uniform preparation of samples with the minimum time and effort.

Courtesy Rose Iron Works, Inc.

Artists Turn to a New Medium

Iron, Steel, Aluminum,
Brass, Silver, Gold for
High Color and Contrast

EDITORIAL

RECENTLY a Chapter meeting was held wherein the relative desirability of gas, oil, and electric furnaces was again discussed, and the conclusion reached by the speaker at the end was "It all depends." Observations in traveling about from this plant to that would almost lead one to conclude that it all depends upon where the metallurgist wants to do his work. If he is content with an old-time, dark, smoky heat treating or forge plant, a poorly insulated gas or oil furnace is endured by the sweating workman. If, however, he does his work in the direct production line, unobtrusive, well-insulated electric furnaces are usually scattered about.

Waste Heat Boiler on Forge Furnace Operates Hammer

Not that there are no gas or oil-fired furnaces which have been built with close attention to fuel economy. Fortunately for that branch of the industry, several of the leading makers are regularly producing equipment that can be placed anywhere in any metal working shop without interference with surrounding operations. One feature of batch operations with oil or gas is inescapable, however — the burned gases must leave the furnace at a high temperature, and carry away (most often to waste) a large proportion of the available heat energy in the fuel. Hence the fuel efficiency is low (seldom reaching 20%) and there is always the problem of disposing of the rest of this heat at the exit.

One of the best ways to utilize it, of course, is to build continuous furnaces, where the spent gases sweep over the approaching cold charge. This scheme may double the fuel efficiency. Counterflow chambers, as for carburizing or baking, may better even this figure, where the completed work can be withdrawn cool. One of the most difficult problems for the fuel engineer is the ordinary forge furnace, heating cold steel to the region of 2200° F., with gases but partly burned in an effort to reduce scaling or surface decarburization.

It would seem that an ideal recuperator for energy wasted from such a furnace would be a waste heat boiler of appropriate size. Such a device was recently observed in a plant on the West Coast, and the idea is worthy of close study. The gas, partially burned, goes hot from the forge into the firebox of a vertical boiler and there meets enough extra air to complete the combustion. Much of the sensible heat is thereafter extracted to raise sufficient steam to operate the hammer. Auxiliary gas burners are installed in the boiler setting to raise steam promptly in the morning, and to keep steam up when the forge fire is dying. This supplementary equipment is automatic in action, since the valves are controlled by regulators actuated by pressure in the steam line.

Over-all fuel efficiency of the forge furnace was reported to be on the order of 5%, whereas the forge and boiler together extract more like 50% of the calories liberated by combustion. Even though few eastern localities have the reason to be economical in the use of gas that exists in Oregon, such a saving is certainly worth getting anywhere.

PRIOR to the discovery of hardened aluminum — say about 1915 — the physical properties of the useful metals were supposed to be constant, as long as they were protected from wastage or corrosion. Failures in service, popularly ascribed to "crystallization" of the metal, did occur with disturbing frequency, but a bar of metal under a moderate and quiescent load, or under no load, was supposed to have the same strength and ductility whether tested the next day after rolling or a year later.

Internal Strain or Age Hardening

Since we have become more familiar with the mechanism of the age-hardening of duralumin, a great number of other instances of this remarkable phenomenon have been discovered. It seems to be a characteristic property of alloys. For instance, small amounts of carbon, copper or nitrogen are able to cause comparatively large changes in the strength and ductility of low carbon steel, changes which may progress with decreasing speed for months and even years. We therefore are looking for small and con-

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sistent changes in the physical properties of metal, and instead of ascribing them to accidental variations or systematic errors, we say "precipitation hardening" and let it go at that.

Mr. Stevenson, in the correspondence pages, draws from his rich experience with high grade steels some data on changes in properties of locomotive tires determined long before the birth of modern metallurgical theory, and reminds us that in those days they were thought to be due to "internal strain" — a convenient explanation, since they knew even less about the real nature and effects of internal strain than we do today, which isn't much. So very little, in fact, that it would be improper to rule it out as the cause of slow changes in metal immediately after fabrication.

Internal strains can, of course, be of such intensity after quenching a tool or after welding a patch that the part will crack — that is, past the ultimate strength. Who is to say what the magnitude of such strains is in a piece which doesn't break? They are perfectly balanced, yet may be strong enough to warp the piece notably after it has been machined. It is presumed that they can be relieved by a heat treatment; precisely what heating and cooling cycle is required? Is a rapidly oscillating magnetic field, or a succession of alternating loads of any value as a stress reliever? What residual stresses are inescapable?

In the face of so much ignorance, the Boiler Code Committee can hardly be criticized for requiring a "stress relieving anneal" on all Class A welded boilers.

It is reasonable to believe that as simple an operation as bending a plate or wire will introduce into it internal stresses up to the "long-time yield point" (that is, the load which the material will withstand without plastic deformation for an indefinite time at the temperature in question). These internal stresses will be balanced and localized, it is true, and fortunately a material having enough ductility to be bent cold can rearrange its sub-surface configuration in a manner which relieves any higher concentrations of load. We know enough about elastic recovery of overstrained metal to know that such rearrangements are slow and take days or weeks to complete. What the effect will be on average properties, like "tensile strength" or "hardness" is now as much a matter of speculation as it was 40 years ago. About all that can be said definitely is that internal stress must not be neglected as a cause of slow changes in metal immediately after fabrication or heat treatment.

Mutual Influence of Furnace Lining and Refined Metal

IN NEARLY ALL textbooks on refractories a list of requirements of furnace brick is given. Infusibility heads these lists; then come strength, toughness, and other physical properties. Sometimes, perhaps as an afterthought, another item "chemical inactivity" is added.

Doubtless, these lists are an appraisal of the qualities demanded at the time, and possessed by the various natural refractories, like fireclay, ganister, and dolomite. In more recent days, with the intensive study of the available materials, the last item of chemical reactivity has been given increased attention. In formulating a special refractory for a special purpose, it may even be the controlling factor.

Not that the interaction between furnace lining and furnace contents has been neglected or unknown. Blast furnace men know that some linings are badly shattered by graphite depositing inside the pores of the brick; in others a carbon deposit on the inner walls forms a self-renewable lining of great protective value. Copper smelter men also build up a protective lining inside a new basic converter by blowing a high-iron matte which splatters the hot walls with magnetite; such linings are practically indestructible because they renew themselves automatically.

Crucible steel makers have long realized that the silica of the pot furnished an essential element in the melt. The wastage of the clay lining in the bessemer converter is also so great that the lining department occupies as much space and men as the steel making operations.

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This very interdependence of the refining process and the container was responsible for the development of the basic bessemer and open hearth. But the emphasis then was upon the *slag*. A basic slag is necessary to carry off phosphorus; a basic lining is necessary to resist scour from the basic slag; hence the basic lining. The corresponding interactions between refractory and metal, or traces of oxide dissolved or entangled in the metal, were passed over with scant notice or mention.

Now that the physical chemistry of steel making is becoming better understood, it is realized that molten metal in the bath is continually working toward equilibrium not only with the slag covering but also with the refractory hearth. A constant interchange of elements is going on, and it would appear that magnesia, for instance, is a good hearth refractory, not because it makes a strong, tough brick impervious to weathering — for it does none of these things — but because it can absorb large quantities of iron oxide and still have good refractory qualities (that is, resist softening or sudden changes in volume at high heat). Alloy steel makers further know that it can also absorb chromium oxide, because if a chromium-free heat is charged into a furnace which has been on chromium steels, the melt will be "salted"; chromium passes from the bottom into the metal in an effort to establish chemical equilibrium.

Undoubtedly, furnace hearths which make a quick succession of specification heats and which are guarded from severe abrasion — as, for instance, an induction furnace melting stainless steel — will work toward the ideal lining. By "ideal lining" is meant one which is in equilibrium with the normal melt; one which neither absorbs alloying elements from the charge nor contributes unwanted portions to the bath. We may look for future developments in the refractory industry in this very direction. Eventually the furnace man will be able to order a lining for cobalt-bearing tool steel, for 18-8, for S.A.E. 4130, and get the same results from his first heat he does from his tenth.

An Eminent Contributor From England

ONE editorial department of METAL PROGRESS which has received much favorable comment is that devoted to Correspondence and Foreign Letters. A steady flow of letters from England, Japan, Sweden, Italy, France and Germany brings intimate information to Americans about developments over there as appraised by experts in the metal industries.

Dr. Cecil H. Desch, who has written regularly from England, is now at Cornell University as exchange professor, and F. G. Martin has been good enough to be a pinch-hitter for him. We are to be congratulated on the news that Dr. Walter Rosenhain has now agreed to write periodical letters from the British Isles.

Few members of the American Society for Steel Treating need to be introduced to Dr. Rosenhain. He has been a most prolific contributor to the science of physical metallurgy, as he has called it. Honors have been bestowed upon him by technical and scientific associations. Many American metallurgists met him when he toured the eastern states some years ago. Some may not know that he has recently resigned as head of the metallurgical department of the National Physical Laboratory — an institution which has similar functions to our Bureau of Standards, and with which he has been associated for about 25 years.

In England as well as America these governmental institutions justify their existence in two distinct ways: First, by solving some of the fundamental problems of industry, and second, by assembling and training a staff of men who later enter industry as specialists and consultants. Often, in the past, informed opinion has deplored the passing of a man from some governmental post (even though it may have been burdened with so much administrative detail as to leave little time for creative or investigative effort), yet has simultaneously congratulated industry upon his acquisition.

So at this time one feels like condoling with the National Physical Laboratory on its loss, yet felicitating British industry on the fact that Dr. Rosenhain is now able to place his gathered experience directly at its service. In this last respect, we also in America will be the gainers.

WELDING OF STAINLESS

and corrosion resistant alloys

by W. B. Miller
Union Carbide & Carbon
Research Laboratories, Inc.
Long Island City, N. Y.

EVERY DAY, designers and metallurgists are turning to high chromium irons and steels for use in equipment that must withstand corrosion and oxidation at high temperatures. As these applications broaden in their scope, a knowledge of the proper procedure for welding the various alloys becomes necessary, since welding affords the most satisfactory method of construction in the majority of applications. These metals can be welded whether they are in thin-gage sheets, plates, or castings. Success can be attained only through a thorough knowledge of the properties of the various alloys when subjected to the high temperatures encountered in welding practice.

A neutral flame just large enough to insure proper fusion should be used, because too much heat causes the molten metal to boil, resulting in a porous weld. A blowpipe flame with excess acetylene increases the carbon content and will lower the resistance of the joint to corrosion. Higher carbon also increases hardness and lowers ductility. On the other hand, an excess of oxygen will cause the formation of a quantity of infusible oxide; it is therefore important that the blowpipe flame be kept neutral.

For sheet 16 gage or lighter, flange welds are usually employed — the edges of the sheets to be joined are bent up to a height of approximately $\frac{1}{16}$ in. This flange is then painted top and bottom with a water-mixed paste of a suitable flux. The flame then melts down the flanges. Occasionally, butt welds are used, using a backing-up strip of some material of high heat conductivity that will not alloy with the base metal.

With a proper flux and with rods of the same composition as the base metal, good welds can be produced in metal $\frac{1}{16}$ to $\frac{1}{8}$ in. thick without beveling the abutting edges. Flux must be applied to the line of the weld both on top and bottom surfaces; this prevents oxidation of metal on the *under* side by forming a protecting film of slag. Without a suitable flux it is practically impossible to obtain complete fusion at the bottom of such a seam.

Joints in heavier gage plate should be beveled and the faces of the bevel coated with proper flux.

Welding should be carried through to completion as rapidly as possible. It should nearly always be done on one side only. While welding on both sides can be accomplished with the aid of a high preheat, this practice is not to be

recommended for ordinary use. Welding rod should not be "puddled," because weak, porous welds will result.

Castings should preferably be preheated to a good red heat throughout. Subsequent cooling should be relatively slow; a final heat treatment may frequently be required to produce the necessary physical properties. Use welding rods of the same chemical composition as the casting. Excess acetylene in the flame is an aid and is allowable for castings which already have a high carbon content. The flame should show only a slight feather of acetylene, but can vary with the type of work. A feather once the length of the inner cone should be considered a maximum; no more excess acetylene should be used than is necessary to facilitate the work.

Numerous efforts have failed to produce satisfactory joints in the various commercial high chromium alloys without a flux; it is needed to dissolve the iron oxide and chromium oxide formed during the operation and to produce a slag that is fusible at the welding temperatures, neither too viscous nor too fluid, since any fluxed impurities should quickly float to the surface of the molten metal. Ordinary welding fluxes will not accomplish these results, so a flux specially prepared for chromium alloys should always be employed. The commercial preparation known as "cromaloy flux" is especially well adapted to this type of work. Surfaces to be welded should always be clean and free from oxide or mill scale.

It should be remembered that the weld metal has very low strength near the melting point; and care should be taken to relieve stresses until the metal has cooled to a red heat and to support the joint to prevent the weld from pulling apart.

These foregoing generalities apply to any of the high chromium alloys. However, before any specific alloy is sent to the welding department, its properties should be carefully considered. The effect of the welding heat and the heat treatment required to produce the necessary toughness and ductility in the weld should be ascertained in advance. A knowledge of the proper heat treatment for the various alloys is essential if the maximum combination of strength and ductility is desired.

For convenience in this discussion, the alloys will be divided into six groups according to chemical composition. Welding data for each group hold good regardless of the variations in chemical composition that may occur within it.

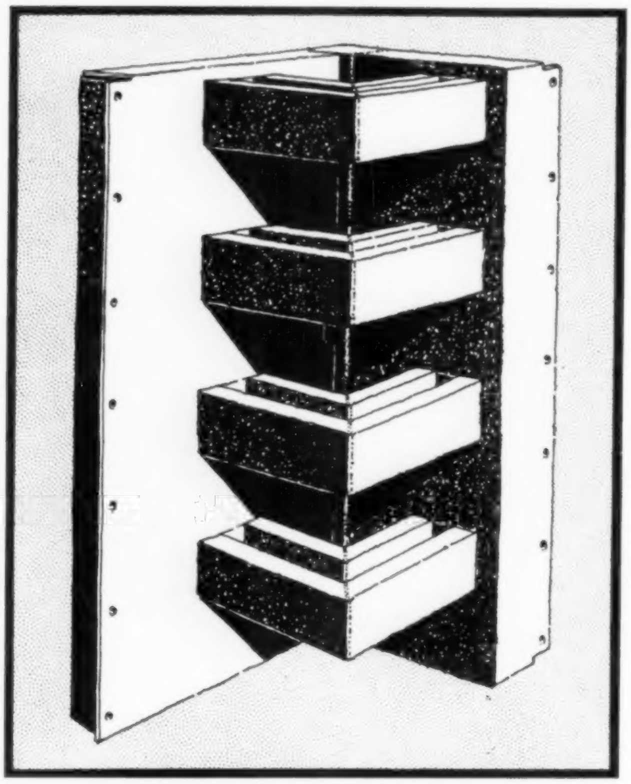
Group I. High Carbon Stainless Steel

Stainless steel is defined by a composition ranging in chromium from 12 to 16%, carbon over 0.20%, and other elements in amounts incidental to the method of manufacture. A typical analysis is as follows:

Carbon	0.33%
Manganese	0.83%
Silicon	0.35%
Chromium	12.75%

Steels of this group are used for cutlery and for heat treated machine parts which must resist general corrosion, wear, and abrasion. The stainless property is very susceptible to heat treatment and to surface finish. On account of their air-hardening properties, welds and metal adjacent will be hard and brittle, which may be remedied somewhat by an anneal, followed by slow cooling. After this treatment, the metal will not have its maximum resistance to stain, which is developed only by a quench

In Thin Sheet Abutting Flanges Are Fluxed and Melted Down



Part of Recuperator Shell With Many Interior Passages, Welded of Ferritic Chromium-Iron Sheet

and draw, followed by proper surface finishing.

Since welds are hard and brittle, and proper heat treatment and surface finish after welding are very difficult, stainless steel is unsuitable for welded parts subject to corrosion coupled with severe stress or vibration, unless the stress is carried by other construction. It has been stated by other investigators that this group of metals will resist stress and corrosion satisfactorily provided the weld metal can be hot worked and the entire assembly given a proper heat treatment to bring out the physical and corrosion-resistant qualities.

Group II. Low Carbon Stainless Steel

Group II, which is frequently known as "stainless iron," is defined by the following composition range: Chromium, 12 to 15%; carbon, less than 0.12%; and other elements in amounts incidental to method of manufacture. A typical analysis is as follows:

Carbon	0.10%
Manganese	0.33%
Silicon	0.39%
Chromium	13.2 %

Differences between Groups I and II lie chiefly in the carbon content, and that a special heat treatment is not required to develop corrosion resistance in the low carbon alloy. The latter resists corrosion of many agents, such as nitric acid and superheated steam, which readily attack iron, steel, and non-ferrous alloys.

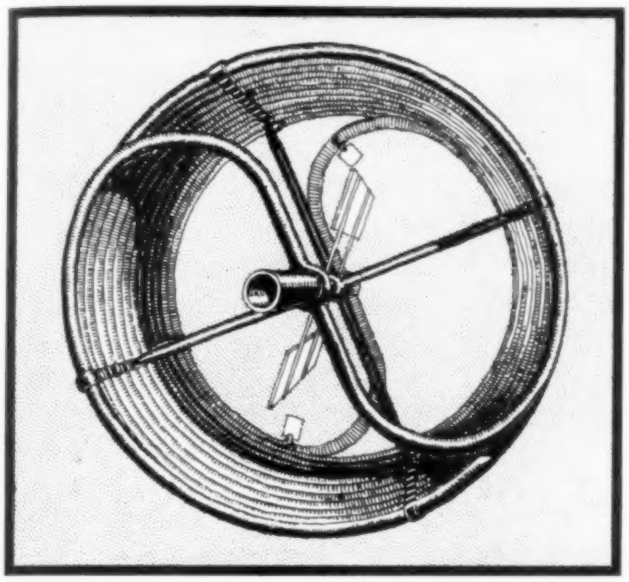
Alloys of Group II are self-hardening or air-hardening when heated above the critical temperatures, 1450° to 1475° F. Welds and metal adjacent to the weld will consequently be hard and brittle, but proper subsequent heat treatment will remedy this to a large extent. Good results are obtained by heating to 1200° to 1380° F. for 30 min. and cooling either in the furnace or in still air.

A welding blowpipe may be utilized for local annealing where suitable furnaces are not available, although furnace annealing is to be recommended. When using the blowpipe for annealing, special care must be exercised to avoid heating the material above 1450° F. The benefit derived from blowpipe annealing will depend on the temperature and the time of heating. Usually about 5 min. within the above temperature range will appreciably soften the metal which has been affected by the heat of the welding flame.

Successful welding of this group of alloys depends upon the proper adjustment of the blowpipe flame. An oxidizing flame (or a neutral flame on the oxidizing side) will produce porous welds. To eliminate this tendency, the flame should be adjusted so it is barely reducing and then the valves turned back so the acetylene feather just disappears. The very slight excess of acetylene which may be present in a flame adjusted according to this procedure will not be sufficient to affect the corrosion resistance of the weld metal.

Group III. Ferritic Chromium-Iron

Group III, also frequently known as "stainless iron," is higher in chromium: Chromium, 16 to 20%; silicon, 0.5 to 1.5%; and carbon, less than 0.12%. This group comprises ferritic alloys; they are more resistant to corrosion than Group II but do not have the capacity for hardening under heat treatment.



Pipe of Various Diameters In Lengths Made of Welded Sheet and Fabricated Into Coils and Fittings

A typical chemical analysis is as follows:

Carbon	0.08%
Manganese	0.29%
Silicon	1.05%
Chromium	17.2 %

Directions for welding given under Group II apply also to this grade. The higher silicon content facilitates the work, alloys containing about 1% being more easily welded than those containing less than 0.5%.

While stainless alloys containing 16 to 20% of chromium and low carbon do not air harden, they are subject to grain growth at welding temperatures. Possibly for this reason welds and metal adjacent to the weld in the higher chromium-irons are considerably reduced in ductility. Blowpipe or furnace annealing at temperatures of 1200° to 1380° F., followed by air cooling, will restore some of this toughness and ductility; care should be taken to prevent overheating on this anneal.

Furnace annealing has improved both the strength and ductility of welds in this type of alloy. Oxy-acetylene welded tubing, after a low-temperature furnace anneal, may be flattened and crushed without cracking in the weld or metal adjacent to the weld. Such tests also show the thorough fusion obtained at the bottom of the seam with the aid of a flux. Annealed welded tubing may also be cold drawn considerably, indicating excellent ductility.

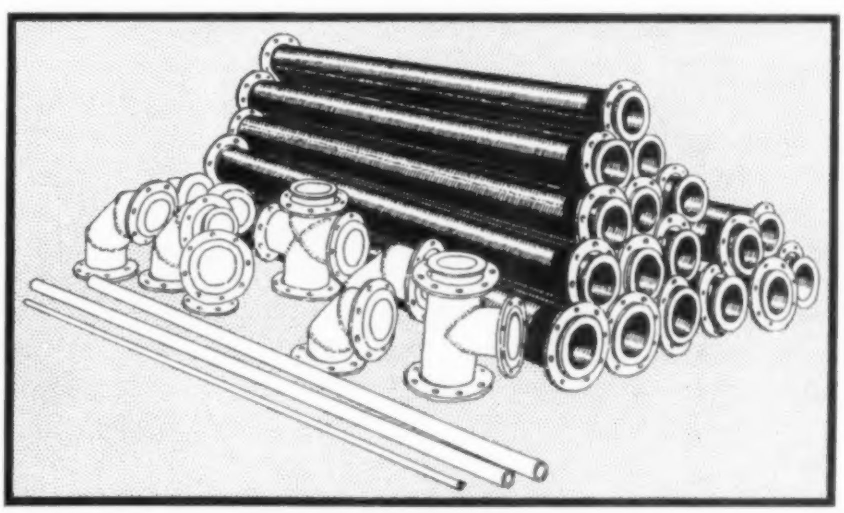
Group IV. Chromium-Nickel-Iron

Group IV is defined by the following composition ranges: Chromium, 17 to 25%; nickel, 7% to 12%. It contains the well-known 18-8 alloys marketed as "Allegheny Metal," "Nirosta, Rezistal, or Enduro KA2." A typical analysis is as follows:

Carbon	0.12%
Manganese	0.32%
Silicon	0.13%
Chromium	17.4 %
Nickel	7.6 %

Alloys of this group are austenitic and are not subject to the brittleness encountered in the previously mentioned types of alloys as a result of the welding heat. They do not air harden; weld metal cooled either slowly or rapidly will possess considerable ductility. Consequently, these alloys are particularly suitable for welded construction, since they require no subsequent heat treatment. The metal can be welded without a flux, but superior results are obtained with it, for only then can good bottom fusion be obtained.

Welds in this alloy show the best combination of strength and ductility in either the



as-welded condition or furnace-annealed condition. Properties of the welds are dependent to a considerable degree on the quality and physical properties of the metal before welding. For instance, moderately cold worked light-gage sheet usually is stronger in the weld than welds in fully annealed material.

Water quenching from high temperature greatly improves the cold working properties of the joints, but on account of distortion, this drastic treatment can be applied only to a few welded products. While water quenching produces the maximum softening effect, air cooling is quite satisfactory for many conditions.

Under severe corrosive conditions this alloy suffers localized corrosion in the base metal next to the weld, regardless of the method used for making the joint. This is probably due to carbide precipitation in that area heated to about 1500° F. A high temperature heat treatment, over 1800° F., remedies this situation and should be used where severe corrosion conditions are to be resisted. If the alloy has very low carbon, under 0.08%, this effect of the welding heat is not so pronounced, and subsequent annealing may be omitted for moderate service.

Most manufacturers of these alloys make two grades of each type, the only difference being in the carbon content. The grade containing maximum carbon, approximately 0.08%, is commonly supplied for welding.

It should be remembered that the 18-8 chromium-nickel alloys have a coefficient of expansion approximately 50% greater than mild steel, and that the thermal conductivity is only 48% that of steel. Precautions such as careful preheating and the proper use of jigs and chill plates will prevent buckling, however.

Group V. High Chrome-Nickel Alloys

Group V is defined by the following composition ranges: Chromium, 7 to 25%; nickel, 17 to 22%; and silicon, 1 to 3%.

Alloys in this group have been developed to meet certain special needs in industry. Each requires a welding technique peculiar to itself, so it is impossible to formulate any specific set of rules. For best results it is advisable to consult the alloy manufacturer for the recommended practice.

Group VI. Heat-Resistant Alloys

Group VI contains high chromium alloys within the following composition ranges: Chromium, 20 to 30%; and carbon, less than 0.3%.

These alloys are characterized by great resistance to chemical corrosion and especially to oxidation at high temperatures. On account of their high chromium content they present some difficulty in welding, particularly on heavy gages, due to the formation of an infusible oxide, but with the use of the proper flux, as previously outlined, very satisfactory flange and butt welds can be made.

Alloys of Group VI are not self-hardening, but grain growth occurs at welding temperatures. Furthermore, they do not possess sufficient ductility to withstand welding stresses if any sudden change in temperature occurs. At a black heat, about 900° F., the alloys are fairly ductile, but if held at this temperature or allowed to cool slowly through this range, they become extremely brittle when cold. Reheating to a red heat and cooling quickly will remove this condition. In any large section it is usually advisable to preheat the entire piece to a black heat and carry welding through to completion in one operation, thus avoiding the necessity of localized reheating.

Welds and metal adjacent will have strength but very little ductility if not reheated above a black heat. This brittleness of weld and adjacent metal is not necessarily an obstacle when it is considered that a great use for this alloy is to resist oxidation at elevated temperatures. Welds and adjacent metal in 20 to 30% chromium alloys are ductile at a good black heat; consequently, brittleness is mostly overcome by and during operations.

Many instances can be cited of welded apparatus performing satisfactorily at elevated temperatures (above 1900° F.). Due to its high chromium content this metal is particularly suited for resisting severe corrosion conditions, such as sulphur fumes at high temperature.

From the above discussion it can be seen that it is possible to weld the high chromium alloys successfully if proper care is taken during the welding operation and during subsequent heat treatment. Understanding of the proper procedure will insure sound welds.

CORRESPONDENCE

and

foreign letters

Birkenhead, England — In these somewhat depressed times, metallurgical interest seems to be centered round the migration of gold. Oh, for an alchemist (British for choice!) who could transmute some of the baser metals into gold!

Quite recently, the scientific world has been celebrating Michael Faraday's centenary. Most people are prepared to credit him with the most marvellous developments of electricity, but it is not so generally known that he also deserves much metallurgical credit. This is amply demonstrated in a most interesting article by Sir Robert Hadfield which draws attention to the fact that before he became an electrician Faraday was first a metallurgist.

Michael Faraday Early Metallurgist

Sir Robert describes how there was stored in the archives of the Royal Institution in London a box of specimens of alloys which Faraday had made. The Royal Institution gave him the opportunity of examining these and he was able to publish his preliminary results in time for the centenary celebrations in this country.

The state of the metallurgical world in Faraday's time was such that it was not able to profit by the work that he did. Apparently, he realized this and allowed the matter to drop. Nevertheless, he was undoubtedly the first to appreciate the importance of investigating the properties of iron alloys on a broad basis, and he may fairly be said to be the pioneer of research in this field.

In the years between 1819 and 1824, Faraday made an extensive and laborious research on alloys of steel with no fewer than 16 different elements. At this time he was assistant in the laboratory and mineralogical section, and superintendent of the apparatus in the Royal Institution. All the alloys with which he experimented were prepared in the laboratory of the Royal Institution, generally with the cooperation of James Stodart, a maker of surgical instruments and cutlery. There is no doubt that Faraday derived considerable assistance from the elder Stodart, but this does not in any way detract from the value of the pioneering investigations.

Apparently, Faraday made small quantities of alloys, although reference is made to the production of some of the alloys "in a large way," sometimes in ingots of 20 lb. Some of them seem to have been used for razors and in the Mint — probably for dies.

Sir Robert Hadfield was given the opportunity of examining portions of each of the 79 specimens which Faraday left. It appears quite definitely proven that he had discovered some alloys which were superior to the ordinary steel then known for cutting instruments, edge tools, and mirrors. Apparently, the only melting apparatus he had was earthen crucibles heated in a coke fire, in which vigorous combustion was maintained by means of hand bellows. How efficient this equipment was may be imagined from the fact that he was able to melt a very low carbon steel. In his work on alloys Faraday made use of chromium, copper, gold, iron, platinum, rhodium, silicon, silver, and sulphur. There is a curious lack of manganese in the alloys, and it is evident that in no melt had this metal been deliberately added.

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A full account of Sir Robert Hadfield's research will be given in a forthcoming book entitled "Faraday and His Metallurgical Researches," the proceeds from which will be presented to the Institution. From what I have already read of the facts discovered, I would recommend this work to all men interested in metallurgy.

F. Grimshaw Martin

High Temperature Resistor Uses Iron-Base Alloy

Stockholm, Sweden — An important expansion has taken place in recent years in the use of industrial furnaces heated by electrical resistors, a development made possible by the utilization of various nickel-chromium alloys. These materials, in the form of wire or ribbon, are nearly always used as heating elements. Various combinations of these elements are quite adequate for hardening, and heating operations at moderate temperatures. For high heats, such as required for tungsten tool steels, non-metallic resistors have been created.

It will be of interest to note that a new metallic resistor (an iron alloy) is now being manufactured in Sweden by Bultfabriks A.B., Hallstahammar, which may be used at considerably higher temperatures than the nickel-chromium alloys now on the European market.

This alloy, which is marketed under the name "Kanthal," contains about 60% iron, the remaining constituents being chromium, aluminum, and cobalt. It is ferritic at all temperatures and consequently undergoes no transformation at any temperature. The melting point is very high, about 1650° C. (3000° F.), and the alloy has a very high scaling temperature, the best quality higher than 1350° C. (2500° F.). Kanthal is made in three different grades, which may be employed up to the following maximum temperatures respectively: Kanthal A-1, 2400° F.; Kanthal A, 2300° F.; and Kanthal D, 1900° F.

In a paper recently read in Stockholm, G. Nordström of Hallstahammar communicated some interesting tests on these alloys.

He finds the three grades to be extremely fire-resisting up to the above-mentioned temperatures. They are also much more resistant to the action of sulphur dioxide and hydrogen sulphide than commonly used nickel-chromium alloys, as can be seen from the following measurements of the increase of weight in grams per square meter of surface after an hour in a stream of SO_2. Kanthal A seems to be unaffected at 1475° F., to gain 1.9 grams at 2100° F. and 6.8 grams at 2300° F. An alloy containing 50% nickel, 33% chromium, and 13% iron gained 2.0 grams at 1475° F., 12.5 grams at 2100° F., and 506 grams at 2300° F. An alloy of 80% nickel, 20% chromium, did considerably better at the above temperatures, gaining 135 grams weight at 2300° F., but it seems to be very susceptible to SO_2 at lower temperatures, gaining 105 grams at 1200° F., a phenomenon not noticed in the other two alloys.

Data on the increase in weight of these same alloys per square meter of surface in an hour's exposure to H_2S were also given:

	1200° F.	1475° F.
Kanthal A	1.2 grams	31.5 grams
Ni-Cr-Fe	56 grams	244 grams
Ni-Cr	92 grams	1182 grams

The electrical resistance of Kanthal is about 15 to 20% higher than the best nickel-chromium alloy tested.

Mechanical properties of the alloy in condition as delivered from factory and tested at room temperature, are: Ultimate stress, 120,000 lb. per sq.in.; elongation, 13%; reduction of area, 65%. At heat the ultimate stress falls off rapidly: At 1300° F. it is 17,000 lb. per sq.in.; at 1650° F., 4700 lb. per sq.in.; and at 2375° F., 575 lb. per sq.in.

Kanthal is at present employed in a number of furnaces in Sweden with working temperatures of 2000 to 2200° F. At Hallstahammar a furnace with Kanthal A-1 corrugated ribbon heating elements was kept continuously at 2375° F. for 500 hr., and although the resistors had been subjected to a maximum temperature of 2450° F., no deformation and only very little oxidation was observed.

Einar Öhman

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Etched Surfaces & Fractures Give Much Information

PARIS, France — Macrography is generally defined as a survey of a plane section taken through the metallic piece, the heterogeneity or the structure of which is to be studied, after polishing and etching. This definition may be extended, because such a study may sometimes be made when the section is not plane nor polished. In fact, the following two modes of operation may be also classed as "macrography," in addition to the conventional methods:

1. Examination of etched surfaces, when the piece is not cut nor broken.

2. Study of etched fractures, when the surface under examination is not polished nor mechanically prepared.

Both of these have been studied at some length by the writer. The first-mentioned permits a non-destructive study of the piece by examining the very surface of the piece, properly etched after smoothing or polishing.

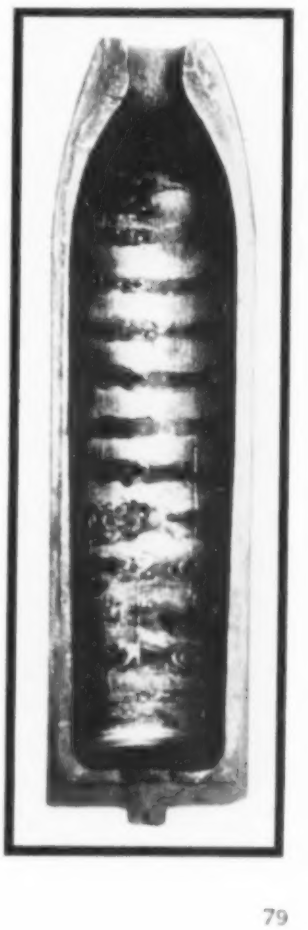
A macrostructural study of castings, particularly of copper and aluminum alloys, will show how the piece was cast, that is, where the gates and the risers were placed. As such a macrographical design is a delicate tracery, the etching must be done on polished pieces, as for nickel plating. I have described these operations in the *Bulletin* of the Association Technique de Fonderie, September, 1927.

Another useful study may be made of the uniformity of hardening in quenched and tempered steel pieces by etching the polished (or only sanded) surface. Proper reagents are the same as those used in micrography, or similar thereto, for example: Nitric acid in aqueous or alcoholic solution or cupric reagents. (In the making of these reagents, wood alcohol may be economically employed.) Oxidation of the entire surface in alkaline nitrate and nitrite baths also gives useful results.

During the War we controlled by this means the action of apparatus used for quenching shells and studied the cause of quenching cracks. The interested reader may consult the account published in 1922 in the *Revue de Métallurgie*, page 267. A view is shown herewith of the interior surface of a 75-mm. shell etched with 2% nitric acid in water. The black zebra stripes are due to irregular quenching from the water sprays, thrown out from a perforated tube inside the hot rotating shell. Obviously, a more uniform state of turbulence in the quenching medium was necessary.

Of course, such an operation discloses only the inequalities of hardening at the surface caused by irregularities in the heating or cooling (principally due to an unequal circulation of the quenching liquid, a quenching bath which is too hot or which contains gases in solution). To study the regularity of internal hardening — that is to say, the hardness penetration — the piece must be divided into sections. However, the cutting of a hardened steel is a long and an expensive operation. Even thin abrasive wheels or tungsten carbide tools must be used with care, else they will involve some heating of the work and consequently cause local temperings and give wrong indications after etching. Fractures, on the contrary, give economical sections of the piece without any local heating.

These considerations lead us to the second mode of operation, namely, etching of fractures. This has already been alluded to in METAL PROGRESS in July. When using this method of study, the metal must not be deformed too much before break-



Etched Interior of Sectioned 75-Mm. Shell Shows Defective Action of Water Sprays in Quenching Fixture

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ing or the appearance of the fracture is too much modified and is too irregular to be etched uniformly.

Etched fractures will give interesting information when the pieces are of hardened and untempered steel, brittle throughout and breaking with no deformation. By etching with the reagents previously mentioned, it will be then possible to disclose the hardening penetration; the non-hardened parts (troostite) color themselves more quickly under the action of nitric and picric acids and are plated more quickly with copper than the hardened parts (martensite). The latter, on the other hand, are colored more quickly by oxides formed in hot baths.

Steel with physical defects, such as cracks, or with a physical heterogeneity, such as important local segregations or inclusions, may be broken without noticeable deformation, producing a surface passing precisely through the defect. This important result does not take place when the piece is cut.

Chemical inequalities may be looked for by means of corrosion tests with iodine reagents, or pickling with strong acids. Silver salt reagents may be used by methods the writer has indicated in the *Journal* of the British Iron & Steel Institute for 1919, page 203. A silver bromide emulsion is allowed to flow over a glycerined gelatin and used in the same way as in the classical method with a sensitive paper moistened with dilute sulphuric acid. This reveals the sulphur-bearing inclusions provoking woody fractures ("cassures ligneuses") in transverse test pieces. This process may also be applied to the surface of detailed fractures of machine parts and laboratory test pieces broken under fatigue stresses.

Considerations such as the above, together with generalizations upon metallographical operations contained in former letters, will establish the fact that much valuable information may be secured from a scrutiny of fractures, either fresh or etched, or of smooth ground surfaces, colored in various ways.

Albert Portevin

Exhibitions Are Now Open Forums for Discussion

Turin, Italy — The speed with which news concerning new inventions and technical improvements now reaches an enormous number of persons all over the world (especially through the technical press) has changed the character and the purpose of industrial congresses and exhibitions. Nowadays, the inventor of a new process or of an important improvement of a known process or apparatus very seldom awaits the next exhibition to make his invention known to the industrial world, because the technical press affords him such an easy and efficient means to describe it immediately to an audience far greater than that which attends any congress.

This does not mean that such gatherings and exhibits do not now have the same importance they had in the past. It only means that their interest now lies in a different direction. Whereas it once consisted mainly in the *novelty* of the subjects reported, the value which accrues to the one who attends the conventions now comes principally from the personal, direct, and complete discussion of these subjects. Furthermore, the practical value of such direct discussion is greatly increased by the great number of researches that are now being made on the different technical problems, and by the much greater complexity reached by those problems.

One can likewise state that the change in character of the technical exhibitions has not impaired their interest and their importance. In fact, quite the opposite is true. Formerly, a visitor found simply some information concerning new processes or apparatus in such exhibitions; now he is able to inspect directly many complex and special applications of new processes and apparatus. He can study personally, and discuss directly with the inventors, the best methods to combine and apply the new inventions to the special technical problems he has to solve.

In other words, the modern technical exhibition is no longer simply a showing of new processes or apparatus (which have already been described by the industrial and trade press), but it is essentially a forum wherein the engineer or supervisor can choose, discuss, com-

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pare, and coordinate different apparatus and processes for the solution of his special problems. In fact, the complexity of modern technical problems is generally such that their solutions can only be found by a convenient combination of different processes.

The same opportunity of making direct comparisons between different processes or apparatus belonging to an associated branch of industry often enables specialists in a given field of industry to find the best solutions for many of their problems in other related technical fields — problems which could not be solved conveniently by methods strictly limited to their special branch of industry.

All these things could be clearly observed in the International Foundry Exhibition, held last month in Milan. Among the apparatus and products exhibited, there was certainly very little which the technical press had not already described. Still, if one followed the lively discussions taking place in the various exhibits, it was evident that the majority of the visitors derived most information from discussing and comparing the apparatus on display and products made by them, which discussions, of course, gave rise to new and useful ideas.

As a concrete example might be mentioned the booth occupied by Josef Polak & Co., of Prague, with an exhibit of pressure die casting machines. Polak machines are known throughout the whole world; they were described (among other publications) in the July issue of Metal Progress, and many large foundries have recently installed them. Two machines were in operation; one (No. 400) was operated by a single man, and can turn out 300 bronze or brass castings per hour, weighing from 2 to 9 oz. each; the total power consumption is only 4 kw., and the cost of labor does not exceed 3% of the selling price of castings. A larger machine made bronze or brass castings weighing up to 7 lb. each, on a power consumption of about 9 kw. Precision of these castings is guaranteed to 0.003 in.

It was in this Polak exhibit that I found the most impressive example of the above remarks, when the head of a large and well-known forging plant, by the careful examination and discussion of the work done by the Polak machines, found that he could very easily and perfectly manufacture some hollow pieces with them, pieces he had unsuccessfully tried to make with his die forging machines.

Federico Giolitti

Properties of Locomotive Tires Change With Age

Ardmore, Pa. — Mr. Ehn's article on "Seasoning of Steel" in September Metal Progress was very interesting, and recalled some facts about the properties of high grade steel which have puzzled me for 30 years or more. Looking back, I find that I discussed briefly a paper by the late W. R. Webster, which he read in the fall of 1898 at a special meeting of the Franklin Institute in Philadelphia, which has a bearing on this matter.

Our ideas on the changes that took place in steel making and treating would appear somewhat elementary at the present time. Mr. Webster was talking about "Specifications of Structural Steel and Rails" and argued (1) that the quality of steel depends upon its chemical composition and (2) on the treatment it received in the course of manufacture. Great masses of experimentation have since verified these propositions, and now enable metallurgists to make a reasonably close numerical relationship between certain of the more obvious factors of production and physical quality. Mr. Ehn's article serves to remind us that not all has yet been discovered about these matters.

One of our early troubles was that we had not even standardized on the method of testing. In my experience at Standard Steel Works Co. in those early days (to quote my discussion of Mr. Webster's paper) "I found a great many tests that were practically valueless for comparative purposes on account of unknown or varying conditions.

"I think it is desirable not only to have dimensions of test pieces and pulling speed

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standard, but also important to have a record of the period elapsing between the time product is finished and tests are made. That a change takes place in steel after finishing, which materially affects the physical results, cannot be questioned.

"In connection with above, the following figures may be interesting. Test pieces were all cut from tires, and duplicate tests, as far as possible, from the same part of the tire, as, owing to section of a tire and process of manufacture, tests from different parts of same section show a variation. Tests were all pulled at the same speed."

INFLUENCE OF AGE ON TENSILE PROPERTIES OF LOCOMOTIVE TIRES

Tire	Yield Point	Ultimate Strength	Elongation	Reduction in Area	Date of Test; Days After Tire was Made
A	53,490 56,037	107,460 108,700	15.0% 16.3	19.2% 24.3	3 13
B	50,940 53,000	99,590 103,464	14.0 18.0	22.2 27.4	3 13
C	56,037 61,130	111,050 111,410	10.0 15.0	12.4 21.5	3 13
D	70,370 71,980	121,250 121,970	11.0 14.0	14.0 17.9	5 12
E	65,080 64,400	121,470 121,160	11.5 13.0	13.6 16.3	7 21

I am unable to give the chemical composition of these tires, although a specification for tires dating about that time called for open-hearth or crucible steel with manganese 0.8% max., silicon 0.2% min., phosphorus 0.05% max., and sulphur 0.05% max., and tensile strength at least 100,000 lb. per sq.in. and elongation greater than 12%. It would be apparent that an inspector might have rejected four of these tires had they been tested too soon after manufacture.

These figures were quoted by Harbord and Hall in the 1904 edition of their "Metallurgy of Iron and Steel," and they ascribed these changes in strength and ductility to the relief of strain due to rolling and irregular cooling, and noted that "some tire makers anneal their tires before despatch" to relieve these strains. This explanation would be accepted by a practical man, but studies on the effect of minor impurities in steel, such as described by Mr. Ehn, throw considerable doubt on the time-honored conclusion.

Naturally one might expect more strain in a tire for a locomotive driving wheel than in a straight rolled bar, owing to the nature of the article, but I know that the same thing that was observed in tires also occurs in rolled bars.

A. A. Stevenson

K.S.Seewasser a Rustless Light Alloy

Schweinfurt, Germany — The development of duralumin and similar high strength light alloys has been of untold importance to the aircraft industry. Successful as these inventions have been, it must be admitted that the alloys do not show a high resistance to corrosion under severe weather conditions. Consequently, extensive experiments have been conducted in Germany with the purpose of devising an alloy that combines reasonably good physical properties with a more or less complete resistance to corrosion.

The most successful of these alloys so far has been called K.S.Seewasser — the two letters K.S. corresponding to the initials of Karl Schmidt, the patent holder and manufacturer of this new alloy. Addition of the word Seewasser, or sea water, speaks for itself.

Chemical analysis of K.S.Seewasser is: Manganese 1.4%, magnesium 2.0%, antimony 0.2%, silicon 0.7%, aluminum balance. Variations in composition within reasonable limits do not materially influence the properties. Manganese can be added up to about 4% and antimony up to 1.2%. Magnesium content may be decreased to about 0.5% with high contents of manganese and antimony. Silicon has an important influence on fluidity at the pouring temperature of 1330 to 1400° F.

This alloy can be supplied either as castings or as rolled shapes. Castings weighing up to 450 lb. have been produced. Rolled products can be obtained in the form of sheets, tubes, or in standard angle bars.

Mechanical properties do not approach those of properly treated duralumin or similar

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strong alloys. As against a tensile strength of 54,000 to 57,000 lb. per sq.in. for duralumin, K.S.Seewasser shows values of approximately 28,000 lb. per sq.in.

The reason for the existence of this alloy is rather in its very strong resistance to corrosion, even under the most exposed conditions. There are evidently many purposes in the construction of aircraft where this resistance to corrosion is of more importance than high strength, and yet where a light alloy must be used, such as auxiliary parts like wing, fuselage, or pontoon coverings, or window frames.

It has also found a considerable use for canning of food stuffs, and also for various applications in the chemical industry.

In the construction of any aircraft it is almost impossible to avoid joining light alloys to other parts of bronze, brass, or steel. When duralumin or silumin is in contact with such other metals, there is a distinct tendency for electrolytic corrosion when sea water or other similar fluids reach the joint. This action has, in some instances, been so severe that failure has resulted. On the other hand, corrosion of K.S.Seewasser under these conditions is practically negligible, so that even after a long exposure, threaded connections can be loosened and parts such as covers can again be secured air or water-tight.

It is evident that the comparatively low strength handicaps this alloy and prevents its wider application for constructional purposes. Intensive research work is therefore going on to develop new alloys that have the same resistance to corrosion, yet also combine high strength. Experiments by Vereinigten Leichtmetallwerken show that this consummation will be reached within the near future.

Alloys with magnesium contents of from 7 to 8% show practically the same physical properties as duralumin, and may even be considered superior, as they are not influenced by intercrystalline corrosion such as affects aluminum alloys containing copper. The composition of these newest experimental alloys is about as follows: Magnesium 7 to 8%, manganese 1.2%; antimony 0.15%, silicon 0.5%, aluminum balance, and iron less than 0.3%.

This alloy may attain a tensile strength of 51,000 lb. per sq.in. combined with an elongation of 18%. As these figures can be relied upon and are not changed through corrosion or internal recrystallization, they compare quite favorably with an initial tensile strength of about 57,000 lb. per sq.in. for duralumin, a figure which cannot be guaranteed against deterioration with age and exposure.

E. W. Ehn
H. Diergarten

Iron-Tungsten-Carbon System

Sendai, Japan — An investigation of the iron-tungsten-carbon system has just been completed by Shuzo Takeda and the results shown graphically in an equilibrium diagram (the data sheet on page 75). In the iron-rich region of this system four phases of compounds exist; namely, $\varepsilon(Fe_3W_2)$, η, WC, and ϑ. The former three are non-magnetic while the last is ferro-magnetic. The η phase is a ternary solid solution which has a composition near that of the double carbide Fe_3W_3C; it is unstable when it contains high carbon, and decomposes into the stable phases WC and iron on annealing or slow cooling. The ϑ phase is also a metastable ternary solid solution mainly composed of Fe_3C, the magnetic critical point of which varies between 0° and 400° C., according to the composition of the alloy and its heat treatment.

It is therefore inferred that there occur two sets of equilibria, (*a*) a stable iron-graphite-tungsten system containing WC, and (*b*) a metastable system of iron, cementite, and tungsten containing the η phase. This assumption controls the lines shown in the figure on page 75.

Nine mono-variant reactions and four non-variant reactions take place in the metastable system. The mono-variant reactions are as follows: Melt $+ \zeta \rightleftarrows \varepsilon$, melt $+ \zeta \rightleftarrows \eta$, melt $+ \varepsilon \rightleftarrows \eta$, melt $+ \delta \rightleftarrows \gamma$, melt $\rightleftarrows \delta + \varepsilon$, melt $\rightleftarrows \delta + \eta$, melt $\rightleftarrows \gamma + \eta$, melt $\rightleftarrows \gamma + \vartheta$, and melt $\rightleftarrows \vartheta + \eta$.

(Continued on page 99)

MODERN BLACKSMITHING

the art of making ornamental iron

by John G. Mapes
Editorial Staff
METAL PROGRESS

MODERN methods of making ornamental iron differ only slightly from those practised in medieval times or earlier, since artistic creation is still best performed by individuals rather than by machines. Of course, electric blowers have replaced hand bellows at the forges, and the forges themselves are now more efficiently constructed, but the changes affect neither the product nor the method of manufacture.

"Wrought" iron products, such as andirons, lamp brackets, and miscellaneous hardware for the home or office, are now usually made from low carbon steel, which has good strength and low cost, and is readily available in numbers of sections. Pieces like fences and gates which are exposed to the weather would ordinarily be made from puddled iron or Aston process iron because of greater corrosion resistance.

Artistic iron is manufactured, to a great extent, in a large number of comparatively small shops, working chiefly upon order and depending upon architects and builders for most of their work. A typical shop for fairly large-scale manufacture of ornamental iron is Rose Iron Works, Inc., at Cleveland, which is headed by a man who has worked iron since he was a boy of 13, many years ago in Budapest, Hungary.

Operations here consist entirely of the execution of artists' sketches into metal. The company employs a designer experienced in the iron working art, but many of its commissions are to reproduce the drawings of architects or the amateur sketches of the customer. Everything is grist for the mill, although it usually happens that non-professional suggestions must be altered to fit the requirements of iron working. Before execution the designs are always redrawn full size and blueprinted, so that the work can be laid directly upon them as it progresses. Accuracy is not as essential as symmetry, except for hinges or similarly fitted parts.

Frequently consulted is an extensive library which covers the history of decorative metal work from early times to the present day. Many other useful volumes refer to closely related arts, such as sculpture, interior decorating, and architecture.

This factory in Cleveland consists of one well-lighted room about 100 ft. square. Four coal forges and a sufficient number of anvils

occupy only a fifth of the total space. Wall benches and assembly tables range around the rest of the room. In one corner is a stockroom in which the metals are stored. Two lathes, a band saw, a circular saw, a milling machine, a shaper, and several drill presses complete the major items of equipment and are the only tools in the shop which are not hand powered. Milling machine and shaper are used primarily for making the tools used in the shop, although, sometimes, to execute a certain design, it is best to mill a piece roughly to shape and finish it by hand with a file or hammer rather than perform every operation manually.

Several metals besides steel and wrought iron are kept on hand. Monel metal is used occasionally, as are stainless steel and aluminum. Brass, bronze, and copper shapes are also stocked. The metals are bought in the forms of sheets, bars, channels, angles, cold drawn and seamless tubing, round bars and hexagonals. Separate divisions of the storeroom are set aside for each metal, but when the man at the forge is not sure whether he has a piece of steel or wrought iron, he lays it on his anvil and strikes it with his hammer a few times. If the hammer bounces high, he knows the metal is not the soft, puddled iron.

Iron screens are much in demand for homes as well as for churches. They represent as much of a problem in assembly as in actual manufacture of separate pieces. The vertical members of the screen shown on page 86 are shaped from soft, open-hearth steel with a carbon content of 0.15 to 0.20%. One-inch bar stock is the raw material, and this is first swaged under the hammer so as to present that rugged appearance characteristic of the oldest existing forms of ornamental iron, and still demanded today.

The photograph shows the top of the 8-ft. bars and the conventionalized leaf design of the top section. The fluted, curving crossmembers each consist of pieces of strip, hot forged to secure the proper camber and bent while hot into the flowing curves specified by the design.

Assembly of a Complicated Piece Is Often as Difficult as Making the Parts

Small inaccuracies in the pieces are eliminated by hammering after the piece has cooled. Preliminary assembly is made by a number of small tack welds made with an oxy-acetylene torch. Complete fusion is not desirable in these tacking welds as it sometimes is necessary to break down the assembly and reshape certain pieces.

Leaves are first sawed roughly from sheet, hot forged into shape, and finished by cold hammering against a lead dolly. Hammers of several shapes are required in this final operation, even in work of simple detail. If intricate designs are required, lead is cast into the shell after hot forging, and the final shaping is done against the resilient lead filling. The leaves shown in the photograph are so simple, however, that they are simply hammered out against the rough lead block.

When working brass, the semi-finished sections are filled with melted pitch or tar, which, upon cooling, becomes sufficiently solid to afford resistance to hammering, yet remains plastic enough to give way under the blows and allow the brass to assume the desired shape.

Frequent Annealing Necessary

Cold worked thin sections of steel must be annealed frequently to prevent cracking. The pounding and the distortion caused by the hammer blows rapidly harden the metal by cold work, so it fractures if it is not annealed often enough. To do this, the work is returned to the forge, heated to the proper temperature (as gaged by eye and experience) and allowed to cool slowly in hot cinders. Heavier sections are always either normalized or annealed before being cold worked. If the cold work is not severe, a normalizing treatment consisting of

forge heating and air cooling proves sufficient.

In the assembly of an intricately conceived piece, it is uneconomical to make all welds by the ancient method of hammering together two or more pieces of white hot metal. Moreover, with the modern development of oxy-acetylene welding, a blacksmith's weld is no longer the only method of homogeneously joining metals. Purchasers of ornamental iron still want the marks of the hammer on the pieces they buy, so many joints are made by the time-honored method.

Many designs are readily executed with the aid of the oxy-acetylene blowpipe which would be impossible if welding in the fire were the only available method. Butt welds are easily made with the blowpipe, and increase the freedom in design. More use can be made of thin sections since the introduction of autogenous welding in ornamental iron manufacture, and both possibilities are lavishly used in ornamental iron of truly modern design, such as the screen already illustrated, in the modern interpretations of older design, and the strictly modern creation shown on page 64.

Five metals are used in this ornamental screen: Low carbon steel, cold rolled steel (polished), aluminum, silver plated and gold plated brass. The combination gives a brilliant color contrast unfortunately incapable of being reproduced in an ordinary photograph. The woman's figure is of hand-formed brass, gold plated. Her hair and the drape over her arm are made of hand-worked brass which has been silver plated. In the photograph, the cold rolled steel can be distinguished from the low carbon steel by its sheen. The very light colored bars in the two outer panels and the leaves are made from aluminum. The leaves and tendrils are gas welded to the stems — a feat impossible in days when forge welding was the only method of joining metals.

Gas welding is also quicker and surer than fire welding, and so the welding blowpipe has an important place in the ornamental iron shop. Fusion welds are usually filed down and hammered lightly to prevent a discordant appearance. Screws and rivets are also used in assembly, particularly for fastening rosettes or other thin-section parts.

Cast ornamentation, such as knobs for railings, has its place in ornamental iron products. Rose Iron Works does not maintain its own foundry because the demand for castings is

Workers of Ornamental Iron Must Be True Craftsmen. Rough-sawed sheet steel is fashioned into a symmetrical rosette by skillful blows of the light hammer. Accuracy of size and proportions is checked by comparing the piece with a full-scale blueprint

small; it does build its own patterns, however, and these are released to small jobbing foundries when occasion requires.

If the design of a piece is copied from an example of the craftsmanship of a long-past year, artificial weathering produces an apparently venerable appearance. For such camouflage, ingenious use has been made of a small light-well in the center of the company's building. Concrete has been laid at the bottom and around the lower sides of the well and a drain of acid-resisting metal installed. Completed jobs which would be improved by the appearance of age are moved into the well, which is actually a tank lined with concrete, and immersed in a weak solution of hydrochloric acid. The finish, which can be obtained in two days, can hardly be told from that caused by years of exposure to the weather.

Another popular finish is obtained by hand rubbing the iron with fine emery cloth to bring out the high lights around the indentations made by the blows of the hammer.

A recent addition to the shop's equipment is a sand blasting machine. The characteristic finish applied by this machine harmonizes well with some designs. Combinations of sand blasted glass with wrought steel are also being tried. The glass is covered with a sheet of rubber-like glue, backed with parchment paper. Designs are traced on the paper and the areas to be blasted are exposed. A bombardment by steel grit lasting from 5 to 20 min., depending on the depth desired, produces an interesting combination of translucent areas set in low relief in transparent glass.

On an average, 25 men are employed in this modern iron works, in addition to executives and office help. Of these, almost all are of the artisan class, having been trained in iron working since the days of their apprenticeship. The workers at the forges are, of course, experienced blacksmiths. Most of the others do the same kind of painstaking work as a jeweler does, although on a somewhat larger, cruder scale.

Scientific methods of cost finding contrast with the age-old appearance of much of the work in process, but an iron-working shop of this kind is dependent upon the skill of its individual workmen for low costs and high output.

CONCENTRATES

from current literature

THAT intense elaboration and specialization of the arts and sciences which is so often remarked is exemplified by metallography. Thirty years ago a single handbook could cover the entire science. Howe was expert in one branch, "Metallography of Steel and Cast Iron," and published his work in 1916. Further specialization justified Greaves and Wrighton's "Microscopical Metallography" in 1925, and subdivision into still smaller units now brings **Handbook of Etching** (Isaac Pitman & Sons, New York, $3.75).

Sponsored by the Society of Swedish Metallographers, of which Dr. Carl Benedicks is president, it represents a search of the literature since 1916 by T. Berglund. Its scope includes preparation of samples of iron and non-ferrous alloys and etching for macro and micro examination. All citations are arranged in logical order, but generally without critical appraisal. The technician making sulphur prints, for instance, will be able to try the various methods proposed and select the one which best fits his equipment, skill, and class of metal under investigation.

It is too bad that two years have elapsed between the completion of the Swedish manuscript and the printing of the English translation. Many more recent notes might have been added to the present book, such as the A.S.S.T. recommended practice for deep etching (50% HCl) described in the *National Metals Handbook*, 1930 edition, p. 415.

SUMMARIES of the papers submitted to the New International Association for Testing Materials held last summer in Zurich are being issued in bound volumes. Group D on "Questions of General Importance" contains several attempts to correlate tensile, hardness, bending, shearing, torsion, and fatigue properties, and to evaluate brittleness or toughness. Four papers on wear tests and equipment indicate that the operation must approximate the service conditions, and the method agreed upon in advance by all parties at issue. In a discussion of the calibration of **testing machines,** it is stated that the accuracy easily possible in tension testing is 1%, hardness 2%, and fatigue 5%. Testing of welds is another favorite topic, an undersized tension specimen or bend tests on butt joints being most highly recommended. A mathematical analysis of stresses in a single lap weld shows that the angle between plate surface and inclined top of fillet must be 60° or more to prevent very high concentrations.

EARLY attempts at the transmutation of matter failed because the experimenters had no knowledge about the nature of the atom, yet these experiments were responsible for the growth of the science of chemistry. Since the War the old problem has been re-attacked intelligently by numerous physicists, headed by the Englishman Rutherford, using the alpha particles emitted from polonium or other radioactive substances for projectiles to bombard the nucleus of an atom. Karl K. Darrow, in *Bell System Technical Journal*, for October, has condensed an enormous amount of highly technical material into an article on **Transmutation,** and in so doing gives an understandable account of some of the experimental methods which indicate that when an alpha particle penetrates the flock of electrons surrounding the

atomic nucleus and collides with the latter, a single particle of positive electricity (proton) is split off, but the alpha particle is fused with the remainder, raising its mass by a corresponding amount. Thus nitrogen (mass 14) loses one proton but gains the alpha particle (mass 4), becoming a new element of mass 17, which is an isotope of oxygen, indistinguishable chemically from common oxygen of mass 16. So far, only the elements lighter than postassium have been disintegrated or transmuted in this manner.

MOST of the steel-making literature of today concerns the operation of the open-hearth or electric furnaces. Prof. R. S. McCaffery of University of Wisconsin recalled attention, at the meeting of the American Iron and Steel Institute last month, to the possibilities of the **bessemer** process. This has retained a position in the manufacture of low carbon steel for such uses as skelp, sheet and tin bar, (where phosphorus up to 0.11% is desirable) and for screw stock (where sulphur of 0.10 to 0.15 is wanted). The author believes that ample ore reserves are available, that large economies in production are to be found in larger vessels, equipped with 50% more tuyeres, and blown with larger volumes of lower pressure air from individual blowers. While most bessemer metal is cast into rimming steel, wherein most of the deoxidation takes place in the mold, there are distinct possibilities of making cleaner, denser bessemer steel by holding the metal in the vessel and deoxidizing there with mixer metal, liquid spiegel or ferromanganese — in other words, utilizing the information recently acquired at Pittsburgh and elsewhere about the physical chemistry of the refining reactions.

Fortune, September, gives detailed **costs** of making sheet steel in the Chicago district. A summary is: Ore, laid down, $4 per short ton. Coke per ton of iron, $4. Total cost of pig iron, $14.50 per ton. Open hearth steel (using 50% pig iron, 50% scrap at $11 per ton) costs $20 per ton in the ingot, and rolling to sheet bars costs $6 more. Rolling to 24-gage sheet, less credit for scrap, brings the cost to about $50, to which must be added fixed charges on plant ($6 to $12 per ton, depending upon the volume of operations.)

WHILE some machine parts are made of steel castings, forgings, malleable or gray iron castings simply because the original designer, years ago, called for that class of material on the blue prints, the recent competion from welded assemblages has reawakened the steel foundrymen to the ever-present competition between materials. In an article entitled "Some Technical Pointers for Steel Castings Salesman" in *The Steel Founder* for October, R. A. Bull states clearly the pros and cons for each of these materials. A decision **forging vs. casting** will usually be made on three considerations: "Number of pieces required, expense including machining, and hazard as to internal defects." The essential difference is grain size; the larger grain of the properly designed and well made casting and its uniformity in all directions (as compared to the inner structure of a corresponding forging) is responsible for the superior performance in high temperature high pressure service (higher "creep" values), and in resisting severe erosion.

NOTES on **early heat treatment** practice are contained in the leading article in *Mechanical Engineering* for November, a biographical note on Jacob Perkins, the inventor of the method of engraving bank note and postage stamps so intricate that it would cost a counterfeiter more to reproduce them than the job was worth. The first plates were assembled from short wrought iron bars, carefully fitted and assembled into a square frame. "So difficult was it in those days to procure iron without flaws that a ton of iron had to be cut up for one plate." After engraving, the plate was case hardened. The design was duplicated by rolling a cylinder of softened steel to and fro across the surface until the whole impression was seen on the cylinder in relief. This cylinder was then hardened and rolled across a plate of copper or soft steel until a perfect facsimile was produced. Such a piece of steel was first softened by packing in a box with pure iron filings, heating four hours at white heat, and cooling in the furnace. After the design was cut or impressed, the plate was recarburized, quenched, "and the temper finally reduced by heating over a fire until it acquired such a shade of color as fit." *(Continued on page 92)*

BECAUSE OF THIS SPIRIT

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The loyalty of these people to the ideals of their work is reflected in every phase of your telephone service. It shows in the increasing speed with which your local and long distance calls are completed. It shows in the greater accuracy with which they are handled. It shows in the wider and more convenient facilities which are placed at your command—extension telephones, intercommunicating systems for home and office, small and large switchboards, teletypewriters and many others.

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CONCENTRATES

USERS of thermocouples made of unusually heavy wire or with unusually long twists or bulky terminals have doubtless had misgivings as to the effect of temperature gradients within the junction. N. P. Bailey has studied the "Response of Thermocouples" *(Mechanical Engineering* for November) and finds experimentally that the temperature of the point of separation is registered by the **thermocouple** no matter whether the rest of the twist is hotter or cooler. In butt-welded joints, the mean temperature of the surface of contact will be registered. The lag behind the surrounding temperature is due entirely to the resistance of a stagnant layer of air on the surface of the couple wires, and therefore depends upon the circulation existing in the atmosphere. Equations for the general case are given. A specific example might be a couple of butt-welded 0.005-in. wires. If it is placed in still air whose temperature is rising at 10° per sec., after a transient period of 3 sec. it will lag 7.7° behind its surroundings. In a stream of air moving at 100 ft. per sec. the lag would be 1.9°.

A GREAT NUMBER of tests for "Deep Drawing Qualities of Sheet Metal" are noted by H. W. Gillett in a correlated abstract in *Metals and Alloys* for October. None of these tests have been accepted generally by manufacturers or users of sheet. The nature of the **deep drawing** operation is such that sometimes strength, sometimes localized ductility, sometimes general extension (or a combination of such qualities) is the critical factor. A useful test must determine the ability of the sheet to withstand the critical factor for a given operation. It will therefore probably result that no universal test can be devised. It is suggested that lots of steel having "good" drawability and other lots having "doubtful" drawability be divided and sent to cooperating laboratories and plants where standardized tests may be made and the results appraised in the light of data on performance in the plants, taking also into consideration such operating differences as forming speed, lubrication, and die design.

OXIDIZED non-metallic inclusions, surrounded by free ferrite, cause 90% of the **valve spring** failures not due to overstressing or poor heat treatment, in the opinion of Frank Stones (*The Iron Age*, Nov. 12). When some of this ferrite approaches the surface of the wire, a tiny patch of soft metal with only about half the desired endurance limit exists near the location of the highest stresses, and failure will be rapid. Since nearly all high carbon spring wire, hardened and tempered, has a laminated or banded structure, or contains many ghost lines, these structures, which are doubtless inherited from inhomogeneity in the ingot, are not a direct cause of the occasional failures. Conventional tests on both ends of each coil of spring wire cannot be expected to eliminate anything but badly defective material. The author notes with approval a German machine which runs a bank of 96 valve springs for two days at operating speed and 110% normal stress; after this run-in there should be little risk of failure in service.

CADMIUM plated wire has definite advantages, according to C. H. Hoff in *Wire* for November. **Cadmium plate** is bright as polished aluminum, fairly dense, and ductile enough for the plated steel to be drawn, cold rolled, or formed without chipping or peeling. Using a bath of cadmium cyanide, current density of 30 amperes per sq.ft., and anodes of pure cadmium, the deposit will build up at the rate of 0.00005 in. per min. Mr. Hoff says that hydrogen embrittlement can be practically eliminated by using inhibitors in the pickling tank that reduce the rate of acid attack on bare iron to 95% that normal, and by depositing the cadmium under such conditions as to give a current efficiency approaching 100%. In this manner, very little hydrogen is liberated in the process, and, consequently, very little can be absorbed by the steel.

A 250-PAGE BOOK reports progress of the Joint Corrosion Committee of the British Iron & Steel Institute and National Federation of Iron & Steel Manufacturers since its organization in 1928. Its avowed object is ambitious: "To explore the entire field of **corrosion** of all types of ferrous products," *(Cont. on p. 96)*

Originated by National

The Short Bed Frame

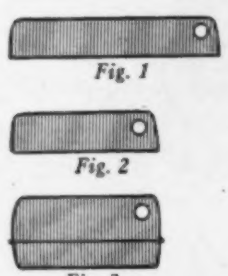
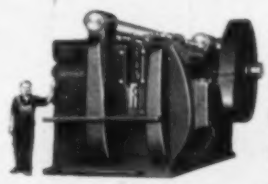


Fig. 1

Fig. 2

Fig. 3

The long, shallow bed frame, Fig. 1, stretches more than the short, shallow bed frame, Fig. 2; But the short deep bed frame, Fig. 3, stretches and springs least of all.



National Bed Frames are the shortest to be found on forging machines. On the huge 5-inch bed frame shown, the distance from the crankshaft to the dies is no more than the width of four men. *A short bed frame is the strongest and most rigid.* National Bed Frames are the shortest. And yet, in spite of their shortness, they are the heaviest of all bed frames. Powerful and compact, they hold dies and slides in the rigid alignment which is necessary for accurate, close-limit forging.

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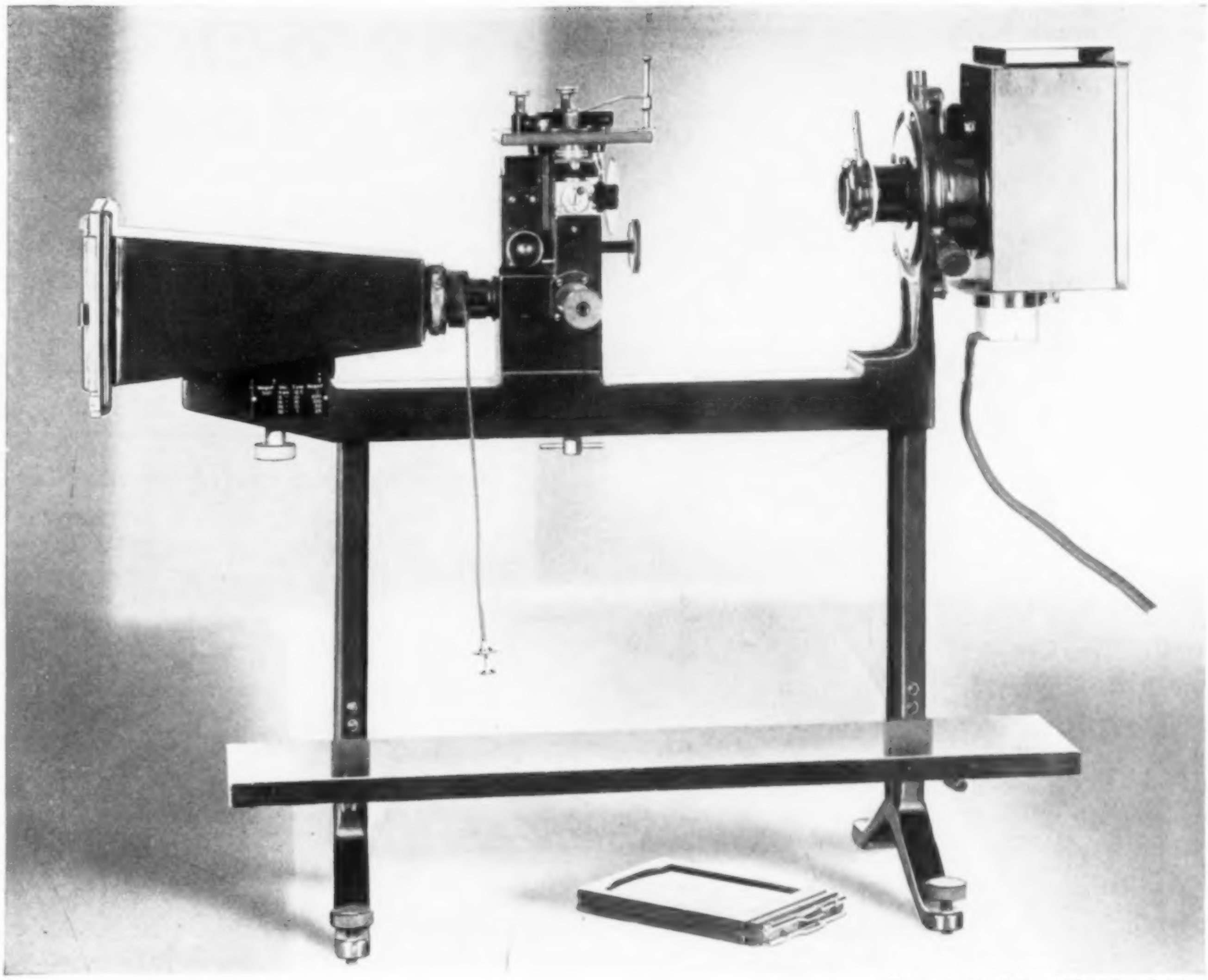
CONCENTRATES

in so far as is not being done by some dozen researches now under way in various countries. Contained in the book is a well-written summary of the present state of knowledge on the mechanism and chemistry of corrosion, and a much longer digest of published material on copper-bearing steel. The Committee supervised the manufacture of heats of three varieties of 0.20% carbon steel — copper free, and with 0.25% and 0.50% copper — and is exposing ⅜-in. plates in 19 conditions of surface preparation or protection in 13 locations throughout the Empire. (A.S.T.M. exposed low carbon copper-bearing steel sheets.) A standardized laboratory test has been devised which will give check results on duplicate samples of scale-free material, and which will establish an order of merit that checks fairly well the results of exposure in industrial atmospheres. In such intermittent spray tests a "standard" mild steel, prepared for the Committee, is used for a control.

WELDING of 18-8 by resistance methods (spot, butt, or flash welding) into a sound, strong joint is easier than **welding** the high chromium stainless alloys, according to Malcolm Clark in *The Welding Engineer* for November. Metal at the joint, however, is liable to corrode very readily, as may be proven by immersing it in hot nitric acid. In order to avoid this defect, heat at the joint must be strictly localized and the heated area rapidly cooled to a dull color. These objects are attained by using clamping dies of generous area, holding the work tightly (pressure up to 3000 lb. per sq.in. of die contact), increasing the secondary voltage, speeding the automatic control of the welding cycle to about a third the time required to make a sound weld in a hand-operated machine, and retaining the work in the clamps until cooled. This practice avoids hot spots near the joint and prevents a "run-back" of heat from the area of the weld.

"SOME Methods and Effects of Machine Gas Cutting" were discussed by L. M. Curtiss before the meeting of the International Acetylene Association held in Chicago last month. Since slabs 28 in. thick have been cut fairly smoothly, it is safe to say that any thickness of steel required by fabricators can be cut by such equipment. **Flame cutting** to templet is quick, simple, and adaptable, and far exceeds the limit of cold shearing. Changes taking place at the flame-cut edge are a carbon enrichment of 5 to 20 points, grain growth, and sudden chill. The result is a hardened surface; microstructure is large sorbitic grains surrounded by thin ferrite envelopes. This is liable to cause surface cracks when the carbon in the original plate is higher than 0.30%, or in alloy steel. Such material should be heated to 600° F. before cutting. Cut surfaces of low carbon steels should be annealed or some metal removed by milling or grinding if the edge is to be bent, or if it is the location of high or alternating stresses. Depth of the zone affected by the heat is proportional to the thickness of the plate, on the order of 0.02 in. per inch. Seldom, therefore, will it be necessary to do much more than smooth out irregularities on the cut surface.

WEIGHT reduction by clever designing and by using **light metals** and special alloys is one of the outstanding developments in the automobile buses exhibited recently at Atlantic City, according to C. W. Stocks and E. F. Theisinger in *Product Engineering* for November. In one design for city service, aluminum alloys constitute 25% of the gross weight; the frame is of structural aluminum alloys with machined joints bolted together. The use of well-proportioned steel bracing and fabricated members of pressed steel is more prevalent. Seats made of magnesium alloy castings and forgings reduce the weight of this detail to 15 lb. per passenger, one-quarter the weight of the steel seat frames formerly used. Brakes are the most abused detail on passenger buses; drums are almost exclusively of high test or special gray iron castings (sometimes with fins for air cooling) or of steel webs with renewable cast iron lining sleeves. Positive ventilation by motor-driven fans is also noted; exposed parts inside the bus are usually made of chromium plated steel, exterior parts of lead-clad steel.



(Photograph made with Bausch & Lomb Protar Lens)

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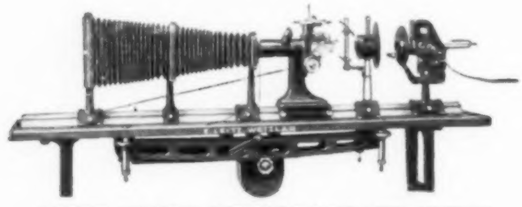

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CORRESPONDENCE

(Cont. from p. 83) The first non-variant reaction, melt $+ \zeta \rightleftarrows \varepsilon + \eta$, occurs at temperature and composition limits not yet determined. Others are, melt $+ \varepsilon \rightleftarrows \delta + \eta$ (at 1380° C. and 28% tungsten, 1.0% carbon), melt $+ \delta \rightleftarrows \gamma + \eta$ (at 1335° C. and 27% tungsten, 1.4% carbon), and melt $\rightleftarrows \gamma + \theta + \eta$ (at 1085° C. and 17% tungsten, 3.7% carbon).

The existing range of the γ phase, which is restricted to less than 6% tungsten in the iron-tungsten system, extends toward the higher tungsten side with an addition of carbon. In this region three binary eutectoid reactions are found to occur: $\gamma \rightleftarrows \alpha + \eta$, $\gamma \rightleftarrows \theta + \eta$, and $\gamma \rightleftarrows \alpha + \theta$.

A peritecto-eutectoid reaction also is found $(\gamma + \eta \rightleftarrows \alpha + \theta)$ at 730° C. and 1.0% tungsten, 0.9% carbon. Furthermore, a binary eutectoid reaction, δ (or α) $\rightleftarrows \eta + \varepsilon$, occurs in the low carbon region.

KOTARO HONDA

REVIEW OF PATENTS

of interest to metal men

by Nelson Littell
Patent Attorney
22 E. 40th St.
New York City
Member of A.S.S.T.

Refractory Material, *by Joseph G. Donaldson and Henry L. Coles, Hamilton, Ohio, assignors to Guardian Metals Co. 1,820,966; Sept. 1.*

This new refractory metal will resist oxidation at high heat, and has, furthermore, the characteristic of greater strength than ordinary vitreous refractory materials both in the hot and cold state. The alloy is a combination of tungsten and silicon, preferably with the tungsten of a materially higher percentage than that of silicon. The alloy may be obtained while reducing the ores, although preferably by the use of an electric furnace. One of the most satisfactory alloys has a maximum content limit of tungsten at about 95% and the silicon content approximately 0.58%. Another alloy contains 48% tungsten and 45% silicon.

Electrode Holder, *by Homer H. Heckman, Detroit. 1,825,314; Sept. 29.*

An electrode holder for arc welding which is lighter in weight is therefore more easily handled. This holder comprises a main conductor which is connected by means of a suitable cable to a source of current supply. The main member supports a plurality of thin copper plates riveted together. A lever is pivoted to the conductor body and has a suitable handle. The jaw member is carried by the lever, and a spring holds the jaws together. The thin strips provide a sufficiently large current lead with less metal and a larger heat dissipating space is provided by spacing the strips apart.

Decarburizing, *by Walter Schottky, Berlin-Charlottenburg, Germany, assignor to Siemens & Halske Aktiengesellschaft. 1,821,407; Sept. 1.*

In this decarburization process, heat is generated in a crucible of silicon material either by high frequency or by electric resistance heating to approximately 1000° C. Hydrogen gas is preferably continuously blown through the molten or red hot mass of iron to remove the methane. After the termination of the first step the hydrogen is preferably withdrawn by a suction pump, at which time the cooling down of the iron is carried out in a vacuum. The hydrogen is preferably under a pressure of 100 atmospheres.

(Continued on Page 102)

Non-Cracking Steel, *by Benno Strauss, Essen, Germany, assignor to Fried. Krupp Aktiengesellschaft. 1,829,118; Oct. 27.*

Hot gases and vapors tend to crack steels in steam boilers under high temperatures and high pressures. It is thought that the phenomenon consists in the reaction of certain constituents of the steel with the gases, and in steam boilers, for example, the nascent oxygen tends to enlarge the grain boundaries. In the present patent, steel is preferably made to contain about 0.5% to 4% nickel, 0.5% to 2% chromium, and 0.1% to 0.39% carbon. In such a steel the martensite forms very quickly when properly heat treated and the grain boundaries can no longer be detected by an etching test.

Mold Lining, *by James B. Grenagle, Baltimore. 1,827,742; Oct. 20.*

High refractory metals may be cast in this mold lining, such as lathe tools, blanks for making finished cutters, chemical dishes, etc. A cement is prepared by mixing zirconium oxide, celite and asbestos preferably in about equal proportions. These products form a rather stiff paste which may be used as a molding material or lining for the flask. Ordinary brass or alloys containing copper are satisfactory patterns, and the mold may be calcined to a temperature preferably exceeding 1200° F. for a period as long as two days. The expansion and contraction of the pattern affords an easy method of removing it when cool.

Annealing Process, *by James J. Bowden, Warren, Ohio. 1,824,865; Sept. 29.*

For annealing metals, particularly large charges where high-grade and uniform quality is desirable, this process specifies an annealing box which contains the charge of metal to be annealed in a molten liquid, allowing it to remain there until it assumes the desired temperature. By the use of several vats, each containing a different molten liquid, such as sodium carbonate, sodium chloride, sodium hydroxide, etc., a number of different temperatures may be maintained and the annealing box moved from one vat to the other. The annealing box is preferably sealed liquid tight and air tight.

(Continued on Page 104)

Pickling, *by Waldo L. Semon, of Cuyahoga Falls, Ohio, assignor to B. F. Goodrich Co. 1,830,566; Nov. 3.*

An inhibitor for iron and steels is described which relates particularly to that class of inhibitors comprising alkylated thioureas. For example, substituted thioureas such as diphenylthiourea, may be reached with ethyl chloride. The invention claims the class of alkyl substituted pseudo-thiourea.

Hard Steel Alloy, *by David F. Youngblood, San Antonio, Texas. 1,822,792; Sept. 8.*

This tool-resistant steel is especially adapted for jails, vaults and the like. One example of the improved alloy steel includes the following materials: Carbon, 1.6% to 1.7%; manganese, 6.5% to 7.5%; chromium, 1% to 1.5%; nickel, 1.9% to 2.5%; and molybdenum, 0.25% to 0.40%. Such material connot easily be filed, sawed, or drilled, nor is the hardness destroyed by heat. It will withstand heavy blows and strains and is practically rust proof.

Melting Malleable, *by Austin A. Holbeck, Lakewood, Ohio. 1,823,604; Sept. 15.*

This patent describes equipment for producing malleable iron castings in a continuous melting, pouring, molding and annealing plant. Several furnaces are provided at different levels; the first for melting, the second for intermediate heating, and the lowest for heating and holding the metal before pouring. The three furnaces are substantially similar in shape and are provided with communicating conductors for tapping the molten metal from one furnace to the second. The second and third furnaces are air furnaces, each of which has a stack through which the waste heat is conducted. A secondary air line is provided for circulating the air and pulverized fuel through the furnace. Secondary air may be directed into the furnace through other valves. Parallel metal disks project partly into the stack and partly into the chamber, and the air in passing through the chamber is compelled to pass along or between the disks to absorb heat therefrom. Such a furnace will prepare a good quality of malleable iron for continuous pouring with less installation and operating expenses.

(Continued on Page 108)

TRADE PAMPHLETS

TO KEEP YOU ABREAST OF THE TIME

High Speed Furnaces—American Electric Furnace Company. A complete description of their new models of "American" electric high speed furnaces with patented atmospheric control preventing oxidation. Bulletin N-2.

Conveyor Belt Handbook—Wickwire Spencer Steel Co. A new loose-leaf handbook, describing various types of metal conveyor belts for high and low temperatures. This includes the new heavy duty "Alpha" link belt, "Delta" plate belt and spiral type. Bulletin N-37.

Practical Metallurgy for Engineers—E. F. Houghton and Co., Philadelphia. A 435-page book by the Houghton Research Staff, covering practical metallurgy in all its phases. Copies of the third edition are obtainable by sending $3.00 directly to the above company.

Potentiometer Pyrometer—The Brown Instrument Co. 16-page booklet explaining and illustrating the principal features of the new Brown potentiometer pyrometer with special reference to accuracy of operation and ruggedness in service. Bulletin N-3.

"Carbonal Process for Carburizing Steels" is the title of the new 12-page bulletin published by the Hevi-Duty Electric Co. The bulletin describes the results and advantages of the Carbonal process of carburizing. Bulletin N-44.

Fatigue Testing Machine—Thompson Grinder Co. interesting data on fatigue testing and description of the rotating beam type of fatigue testing machine are given in Bulletin D-23.

Heat and Corrosion Resistant Alloys—Michigan Steel Casting Co. A 16-page bulletin describing and illustrating various cast, rolled and fabricated alloy structures for use at high temperatures. Bulletin N-12.

Globar Elements and Accessories—Globar Corp. A new leaflet containing a list of standard industrial type Globar electric heating elements and a coordinated list of terminal mountings and accessories. Bulletin N-25.

Furnace Parts—Driver-Harris Co. has issued a bulletin featuring furnace parts made of their alloys. This bulletin gives data and advantages of Nichrome and Chromax heat resisting alloys in the form of furnace parts. Bulletin N-19.

Automatic Metallographic Polishing Machines—E. Leitz, Inc. Catalog illustrating and describing the Guthrie-Leitz automatic polishing machines of the one, two and four-spindle types. The new Leitz specimen clamps are also described. Bulletin N-47.

"The Path to Permanence" is a newly revised booklet on Toncan copper-molybdenum iron issued by the Republic Steel Corp. It contains 64 pages of interesting installation and metallurgical data on this rust resisting sheet metal. Bulletin N-8.

Scale Prevention—Dearborn Chemical Co. Booklet describing latest scientific methods of treating water for prevention of scale, corrosion and foaming in steam boilers, dealing with related problems in connection with scale and corrosion in other power plant equipment. Bulletin D-36.

Heat and Corrosion Resistant Alloys—General Alloys Co. A new bulletin is available on chrome-nickel and straight chrome heat and corrosion resisting alloys. Bulletin D-17.

Hy-Ten Alloy Steels—Wheelock, Lovejoy & Co., Inc. "Pertinent Points" folders covering physical properties, heat treatment and applications of all grades of Hy-Ten Special Steels. Bulletin D-22.

Gasalyser—Chas. Engelhard, Inc. New bulletin which describes the Gasalyser, a new portable instrument for gas analysis; in addition to gas analysis temperature measurements can be made with the same instrument. Bulletin D-14.

Industrial Gas Heat—American Gas Association. A veritable textbook on the uses of gas heat in industry, profusely illustrated with photographs of installations, etc. Bulletin D-10.

Aluminum Welding—Aluminum Company of America. Instruction card to be hung in the shop for ready

Trade Pamphlets Continued

reference, giving directions for welding aluminum. Bulletin D-54.

Hacksaw-Ology—Simonds Saw and Steel Co. Book illustrating and describing the uses of hacksaws. Bulletin D-69.

Industrial Application of the X-Ray—General Electric X-Ray Corp. Booklet gives many examples of the use of the X-Ray in the industrial field. Profusely illustrated with radiographs of castings, welds, assemblies, etc. Bulletin D-6.

Refractories—E. J. Lavino & Co. Literature on Kromepatch and Plastic K-N chrome ore refractories for industrial furnaces. Bulletin O-40.

Modern Industrial Furnaces—Surface Combustion Corp. Booklet covering the research, development and engineering activities of the Surface Combustion Corp., and their application and the advantages obtained by S-C furnace users as a result of these factors. Bulletin N-51.

Cold Finished Bar Bulletin—Joseph T. Ryerson & Sons, Inc. Bulletin describing the wide variety of shafting screw stock, and open-hearth case carburizing steels in use today. A range of products is given, a list of standard tolerances and S. A. E. specifications. Bulletin O-50.

Welded Construction Folder—Bethlehem Steel Co. Folder describing the use of rolled steel shapes and plates for the building of machinery parts by welding. The results are said to be sturdier construction, reduced weight, low cost, and elimination of patterns. Bulletin N-76.

Case Hardening—Roessler & Hasslacher Chemical Co. New 80-page booklet on case hardening, nitriding, reheating and mottling of steels with R & H cyanides. Also coloring, tempering, drawing and annealing of steels with R & H salts. Helpful charts, tables and methods of analysis included. Bulletin N-29.

High Test Welding Rod—The Linde Air Products Co. A 12-page booklet describing the qualities and advantages of high test welding rod. Extensively used for fabrication of pipe lines, pressure vessels or other welding operations where high strength and economy are required. Bulletin D-63.

Ferro Alloys and Metals (Third Edition)—Electro Metallurgical Sales Corp. Describes current practices with specific reference to the "Electromet" products supplied to the metallurgical industry by this organization, together with suggestions for their use in both the ferrous and non-ferrous industries. Bulletin D-16.

Ingot Molds—Gathmann Engineering Co. The subject of ingot molding is covered in a new book on this subject. Numerous illustrations of the effect of various methods of finishing and casting on the reliability of steel products are given. Bulletin D-13.

Furnaces for the Steel Industry—The Electric Furnace Co. have issued a four-page folder illustrating and listing several electric and fuel fired furnaces of various types they have installed in steel plants. Bulletin D-30.

The Coreless Induction Furnace in the Steel Industry—Ajax Electrothermic Corp. Reprint of a paper describing recent developments in high frequency coreless induction furnaces and their probable applications. Bulletin D-41.

Electric Steam Generators—General Electric Co. Booklet describing and illustrating G. E. electric steam generators for process work. A list of applications is included showing how these generators may be used in a wide variety of industries. Bulletin D-60.

Electric Heat Treating Furnaces—Ajax Electric Co., Inc. Photographic description of new electric furnaces for annealing wrought products, such as sheet, wire, tubing, rod, etc. Bulletin D-83.

Stainless Steels—United States Steel Corp. Booklet describing various stainless and heat resisting alloy steels produced by subsidiary companies. Tables of chemical compositions and physical properties are included, also recommended procedures for use, polishing methods, etc. Bulletin D-79.

Alloy Products—The Pressed Steel Co., in their new catalog, give interesting data relative to Rezistal Lite-Wate carburizing and annealing containers and other equipment. Bulletin D-67.

Thermit Welding—Metal & Thermit Corp. A 52-page booklet on the thermit welding process and its applications. Photographs and descriptions typical of its varied uses are given, showing how Thermit is fundamentally adapted when large sections are involved. Bulletin D-64.

Gears Made of Armor Plate—The International Nickel Co. Reprint of article by Robert E. Bultman originally published in May, 1931, issue of METAL PROGRESS. Booklet deals with the use of 5 per cent nickel and nickel-chrome steels for motor truck gears and pinions. Bulletin D-45.

Carbofrax in Boiler Furnaces—The Carborundum Co. 35-page booklet on Carbofrax refractories for use in boiler furnace construction. Many illustrations show its varied applications and the many shapes and forms in which it may be obtained. Bulletin D-57.

Machine Heat Treating—American Gas Furnace Co. A 16-page illustrated booklet giving information on the various types of conveyor heating machines available for heat treating on a production basis. Bulletin D-11.

Furnaces—W. S. Rockwell Co. Bulletin on electric and fuel fired furnaces for ferrous and nonferrous metals, ceramic and chemical products. Illustrations of many types are shown. Bulletin RO-320.

Pyrometer Controllers—The Bristol Co. New catalog on automatic control of high temperatures, illustrating and describing Bristol pyrometer controllers and their applications. Bulletin D-56.

Bright Annealing in One Operation—Process Engineering Equipment Corp. Leaflet on the bright annealing of blanks and stampings of steel, brass, nickel silver, etc., after which no pickling or cleaning operations are necessary. Bulletin D-81.

Oil and Gas Burners—W. S. Rockwell Co. Bulletin illustrating and describing various oil and gas burners for industrial heating furnaces. Bulletin N-49.

Metal Progress, 7016 Euclid Ave., Cleveland.

Please have sent to me the following literature as described under "Trade Pamphlets" in the December issue of METAL PROGRESS. (Please order by number.)

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Malleableizing, *by Irving R. Valentine, Erie, Pa., assignor to General Electric Co. 1,830,630; Nov. 3.*

By this method of making malleable iron from white cast iron, the white iron castings are heated to a temperature of about 1000° C., which temperature is maintained long enough to cause the cementite or carbon in the iron to go into solid solution. After this, the iron goes through the temper carbon step by cooling from 1000° C. to approximately 750° C. The casting is held in this temperature zone until substantially complete graphitization has taken place. This may vary from four to thirty-six hours, but is preferably continued for about twenty-two hours. If the heat treatment is continued in the 700 to 750° C. zone the tensile strength is reduced and the elongation increased. A shorter period of time may be satisfactory in the second heating zone if the temperature is reduced from 1000° C. to 735° C., maintaining the temperature at 735° C. for four hours, then dropping to 725° C. and keeping at such temperature for four hours, then dropping to 715° C. and holding at that temperature for four hours. Sixteen hours after the initial temperature under such conditions gives a tensile strength of 56,400 pounds per square inch and an elongation of 15%.

Malleable Nickel Alloys, *by Norman B. Pilling, of Elizabeth, N. J., assignor to International Nickel Co. 1,824,966; Sept. 29.*

To improve the ductility and working properties of malleable nickel alloys, particularly for such operations as forging, rolling, etc., an addition of a relatively small amount of an alkaline metal to the alloys is made. Calcium is found to be especially beneficial to malleable nickel, iron-nickel alloys, and iron-nickel-chromium alloys. Other metals such as barium and strontium may also be used. In general the amount of calcium, barium, or strontium required is from 0.005% to 0.5%. A method of adding the metal is by refining and treating the mixture in the customary manner, and just before pouring, the calcium may be introduced into the melt. This is done at this time because the alkaline earth metals are highly volatile and reactive.

(Continued on Page 110)

Wrought Iron, *assigned to A. M. Byers Co., Pittsburgh. 1,820,177; 1,820,178; 1,820,179; Aug. 25.*

These patents relate to the manufacture of wrought iron by the Aston process. Patent No. 1,820,177 covers the manufacture of wrought iron from Bessemer converted metal in which the converter heat is "full blown" so that the carbon is reduced to below 0.10%; and usually to 0.06%. After such formation the metal is poured into a bath of iron silicate slag having a silicon content not materially over 10% and forming a welded puddle ball therein. In patent No. 1,820,178 the invention relates to the discovery that the slag must be carefully controlled which is brought about by charging the slag into a shaft furnace and providing a column therein of sufficient permeability to allow gases to pass up through it and then feeding hot gases of combustion upwardly through the charge under substantially non-reducing conditions, and then melting the material in a hearth furnace under a non-reducing atmosphere. Patent No. 1,820,179 relates to the preparing or remelting of slag by tapping out the liquid slag and making such additions as may be found necessary.

Inhibitor, *by John G. Schmidt, Philadelphia, assignor to E. F. Houghton & Co. 1,807,711; June 2.*

The solvent action of sulphuric acid on iron and steel is prevented by this inhibitor which provides a sulphuric solution relatively inert toward the ferrous metals and therefore capable of being shipped in iron or steel containers. The present invention contemplates the addition of reaction products of aryl thioureas and aldehydes to the sulphuric acid. These include the reaction products resulting from the chemical combination of an aromatic thiourea, such as thiocarbanilide and diortho-tolyl thiourea, and any aliphatic aldehyde, such as formaldehyde, acetaldehyde, propylaldehyde, allylaldehyde, and the like, or aromatic aledhyde, such as benzaldehyde or cinnamic aledhyde, their homologues, isomers or substitution products. One particular reaction product is the result of the reaction between 256 grams of di-ortho-tolyl thiourea, 150 grams of 40% formaldehyde solution, and 200 cubic centimeters of water which is placed in a water reflux condenser. After treatment the crystals of di-ortho-tolyl thiourea begin to disappear and after 16 to 18 hours the reaction is complete and the oily compound is separated from the supernatant water. The new compound is a colorless, heavy liquid, very viscous at ordinary temperatures and very slightly soluble in cold water.

Quenching Oils, *by Hugh Rodman, Oakmont, Pa., assignor to Rodman Chemical Co. 1,818,431; Aug. 11.*

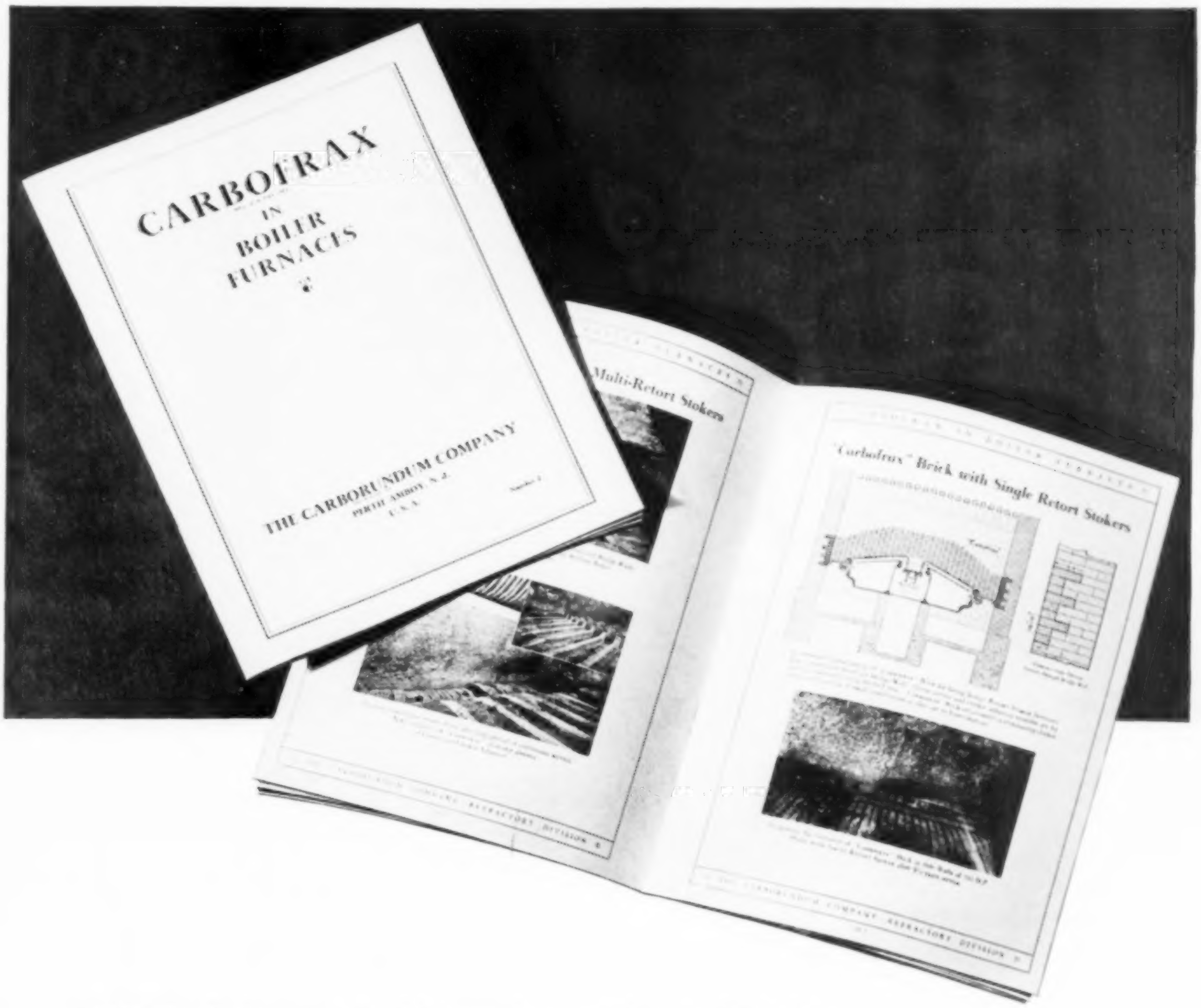
The major object of this patent is the provision of an increase in the quenching speed of certain mineral oils, particularly those of lower viscosity and low flash point. In steel quenching, a mineral oil bath is frequently used which has a low viscosity such as not over 150″ at 100° F. on the Saybolt viscosimeter, but inasmuch as it is desirable to cool the steel rapidly through the critical temperature the oil is somewhat unsatisfactory. If 5% of the solid residuum of vacuum distillation is added to the low viscosity, low flash mineral quenching oils as a base, the viscosity is raised only slightly but the oil has a higher initial quenching rate and is more satisfactory than the usual additive quantities of animal or vegetable oils. Such residuum is completely and permanently soluble in the low viscosity quenching oil, and furthermore is cheaper and easier to use.

Aluminum Alloy, *by Horace Campbell Hall, Littleover, Derby, and Tennyson Fraser Bradbury, Derby, England, assignors to Rolls Royce Ltd. 1,813,850; July 7.*

This aluminum alloy can be cast free from scum and pin holes, particularly on the upper surface. It is found that if a small quantity of metallic sodium not exceeding .01% of the alloy is plunged into the alloy when in a molten condition that such alloy will have an effect of cleaning and de-oxidizing the casting. The preferred process consists in wrapping the sodium in a piece of sheet aluminum or aluminum foil, and so wrapped plunge it into the molten alloy and hold it below the surface until it is diffused. The bulk of the sodium so added is lost through burning at the moment of immersion and only traces of it are left in the castings. The alloy

(Continued on Page 112)

It's Important that You Have this Bulletin in Your Files



JUST off the press is this complete treatise on Carbofrax Brick in Boiler Furnaces.

Between its covers you will find a wealth of practical information on the use of high refractory brick—detailed illustrations and descriptions of various types of installations—data on the construction and performance of the newest types of air-cooled and water-cooled walls. In other words, this is indeed an important work on the subject of efficient boiler furnace linings.

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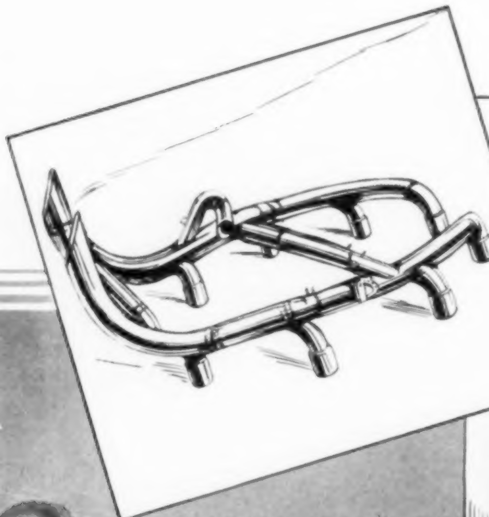

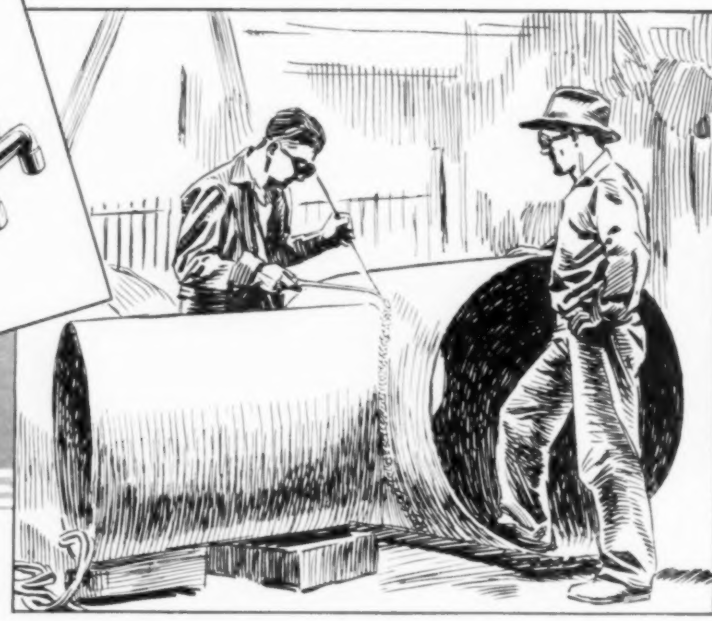

From plan to production

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YOU are privileged to call upon Linde Process Service for assistance and advice in any phase of your operations wherein you use Linde Oxygen for welding and cutting.

This service brings to you the wealth of welding experience Linde has gained over many years of pioneering the oxy-acetylene process. It supplements the work of your own engineers in organizing your welding and cutting operations for maximum speed, economy and dependability. It injects the best practices of the day toward the solution of your specific problems.

Here are some of the numberless things Linde Process Service has done:

> It assisted a contractor in relocating piping under a narrow street during subway excavation. Linde Process Service helped to plan a flexible system, permitting changes as the subway progressed, and helped in securing strong welds which withstood severe abuse.
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> It helped a manufacturer make pipe for chemical use from sheet aluminum. It supervised the welding routine, trained welders and suggested short cuts which speeded up production.
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> It assisted an automobile body manufacturer in maintaining schedules by integrating cutting and oxwelding with other production processes.

Whether you are adopting the oxy-acetylene process as a new user or are seeking additional advantages from its further application, Linde Process Service can help you. This service is "service" in the fullest meaning of the word. Write or call the nearest Linde District Office.

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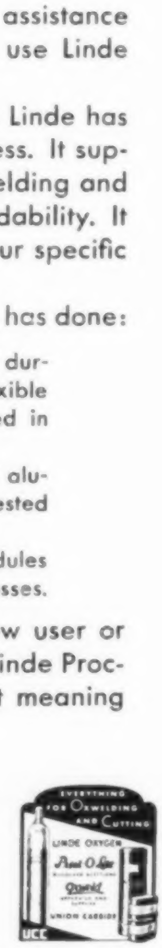

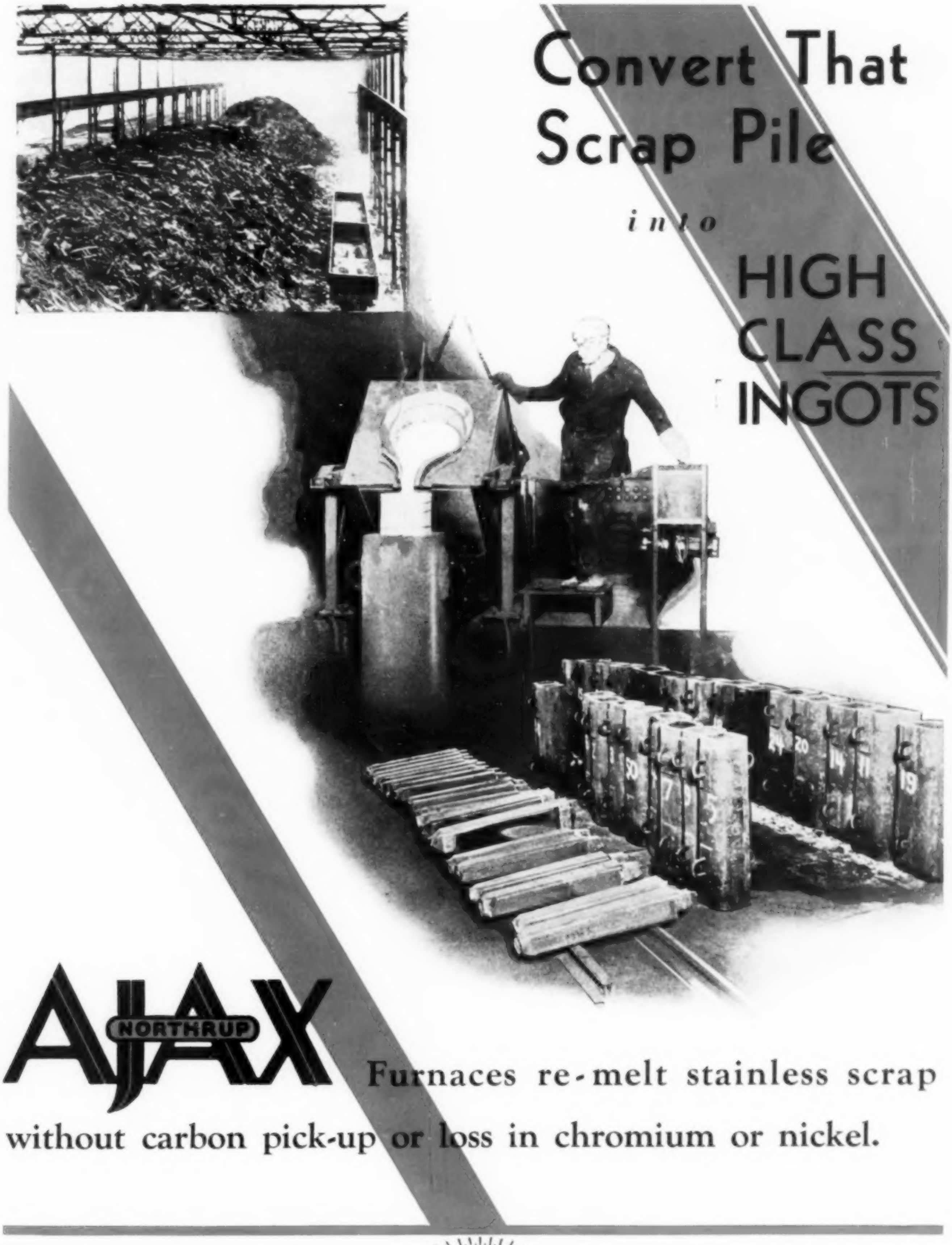
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Scrap Pile
into
HIGH
CLASS
INGOTS

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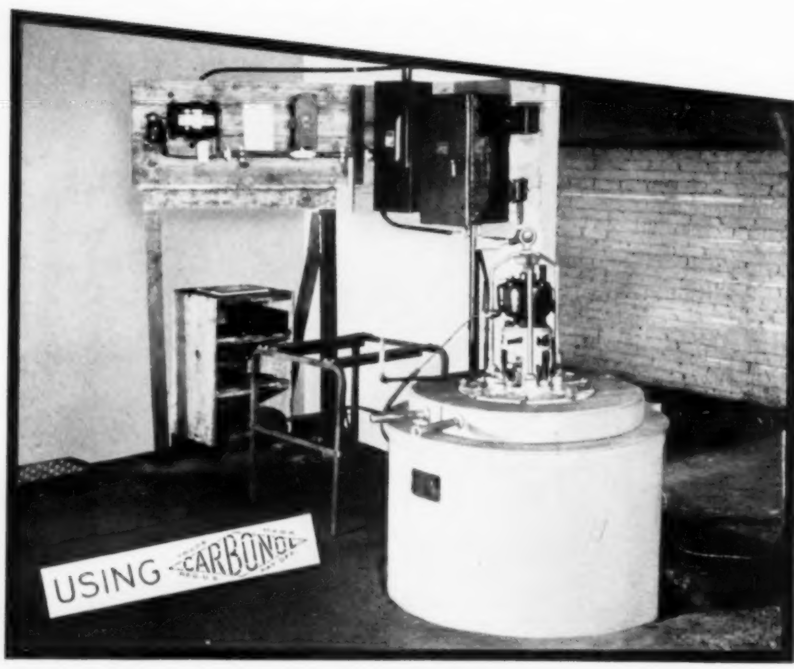

AND STILL ANOTHER JOB FOR CARBONOL AND THE ELECTRIC VERTICAL CARBURIZER

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Mesh-belt conveyor furnace in the plant of a large typewriter manufacturer

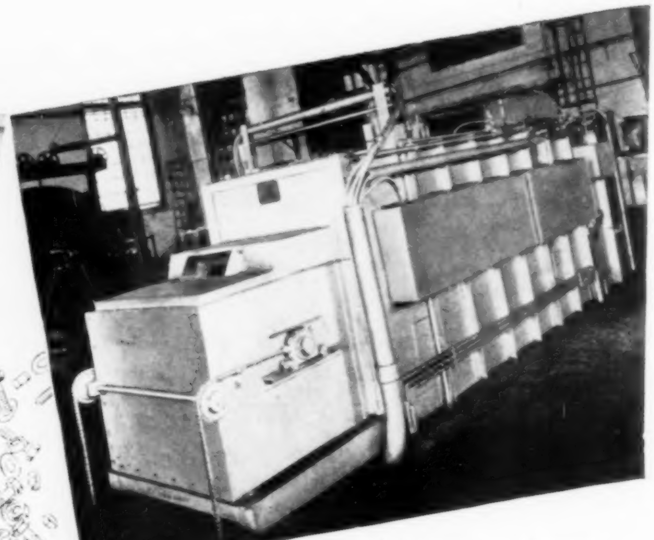

Plate-belt conveyor furnace in the plant of a prominent steel manufacturer

MODERNIZE the heat-treatment of miscellaneous steel parts with G-E electric conveyor furnaces

You know the remarkable economies effected by automatic machines in your plant.

You will be glad to know, then, that General Electric has converted electric furnaces into automatic heat-treating machines — highly efficient, compact units that include even the quench tanks.

Standard sizes of these machine furnaces are available in capacities of 200 to 1200 lb. equipped with either mesh-belt, link-belt, or plate-belt conveyors, depending upon your requirements.

The electric units are readily removable. The design excludes annoying air currents and provides for a smooth temperature rise from the charging end to the discharge end, the temperature at the discharge point being rigidly maintained for the most effective quenching.

The furnaces are remarkably flexible, handling a wide range of products, and often doing an amount of work formerly requiring several batch-type furnaces and operators.

Write your nearest G-E office for all the facts.

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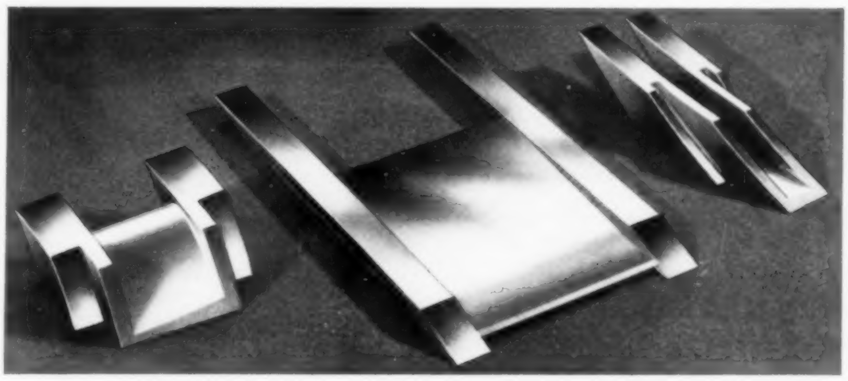
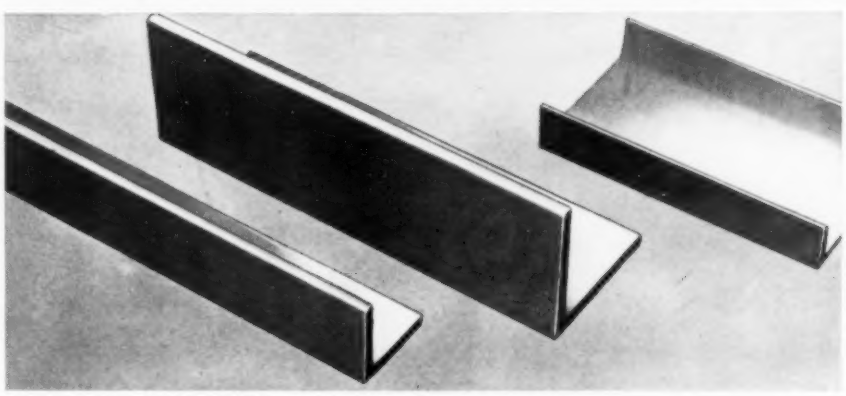
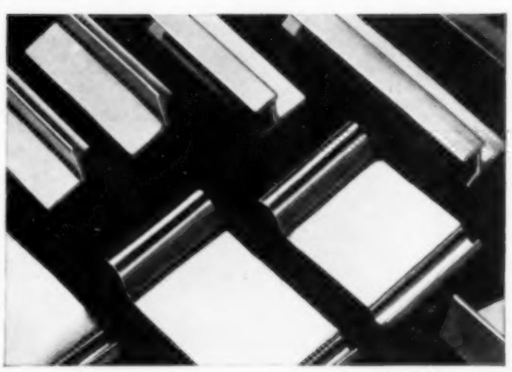
BETHADUR

MEETS EVERY REQUIREMENT FOR CORROSION-RESISTING STEELS







Top: Steam turbine nozzles made of Bethadur

Center: Structural shapes of Bethadur

Lower: Automobile rim and window sash sections of Bethadur

The nine grades of Bethadur, with Bethalon, so well known for its easy-machining properties, provide a complete line of corrosion-resisting steels among which you can find one just suited to practically any requirement for this kind of material.

Over a period of years Bethlehem has been conducting a vast amount of research in the development of these steels and in handling them through manufacturing processes. A wide variety of products has been made of Bethadur among which are included such items as steam-turbine blades and nozzles, automobile rim sections, wire-wheel spokes, window-sash sections, streamline wire, angles, channels, and numerous others.

Though large quantities are now being used, corrosion-resisting steels are just beginning to come into their own. There are many places in products of all kinds where they could be advantageously used. If you have a possible use for corrosion-resisting steel, consult Bethlehem metallurgists about the possibilities in Bethadur.

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BETHLEHEM STEEL

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Before the development of BRISTOL'S Recording Absolute Pressure Gauge, absolute pressure generally was computed by subtracting from the barometric pressure the vacuum which the gauge indicated. Two observations, barometric pressure and vacuum, were always needed before absolute pressure itself could be determined.

Now BRISTOL presents to industry a new Recording Absolute Pressure Gauge that gives an accurate continuous 24 hour record of absolute pressure, automatically compensated for barometer fluctuations.

This remarkable recorder possesses these four features:

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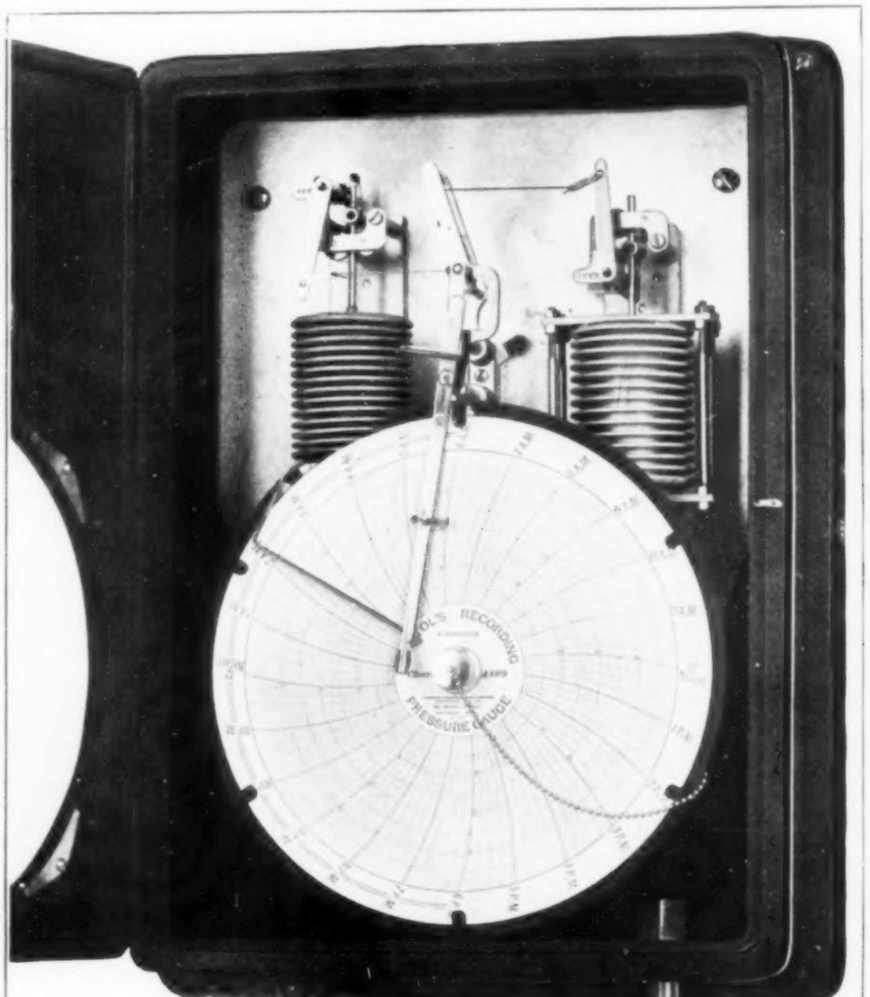
This is essentially a cross member, pivoted at the middle to a rigid extension of the pen arm, and connected at the ends to the two sensitive actuating elements. It swings freely. It correlates the motions of the two sensitive elements, and communicates to the recording pen arm the differential motion which is directly proportional to the absolute pressure.



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Both the barometer element which is hermetically sealed and the element which is connected to the vacuum are extremely sensitive to the slightest variations in pressure. These elements respond to fluctuations by expanding or contracting with a linear movement. The motions are transmitted by a suitable linkage to the pen arm.

PEN ARM AND CHART:

The chart is accurate throughout its entire range. Graduations are in tenths of an inch of mercury column. Readings can easily be estimated to hundredths.

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Precision measurement of absolute pressure is of great importance to industry. In the manufacture of products ranging from electric lamps to perfume, in petroleum refineries, steam turbine plants, in food packaging processes, in fact wherever operations are carried out under a vacuum, the value of recording absolute pressure accurately cannot be overemphasized.

You will want further information about this new achievement in precision pressure measurement. We shall gladly send you facts and figures. Just fill in and return the handy coupon.

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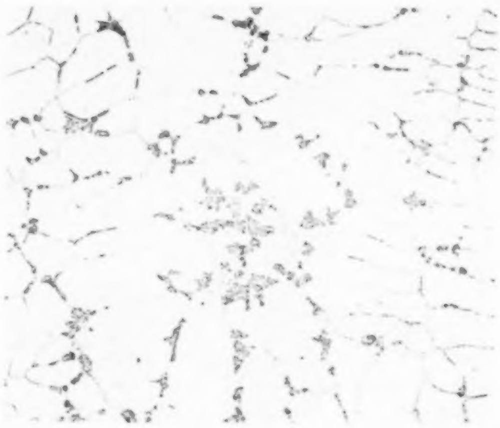
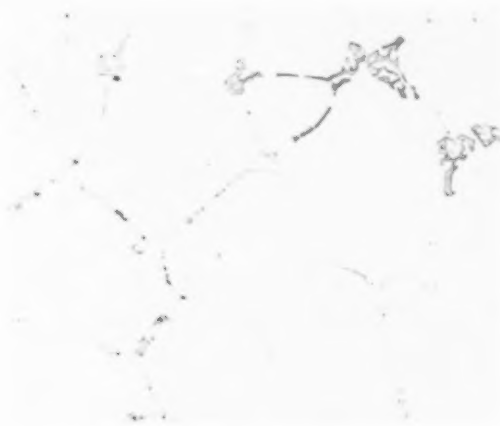
Etched With 1.5% HCl, 1.0% HF, 2.5% HNO_3 in Water





Typical As-Cast Ingot Structure. Magnifications 100 and 500 diameters. Shows micro-grains and $CuAl_2$ (light).

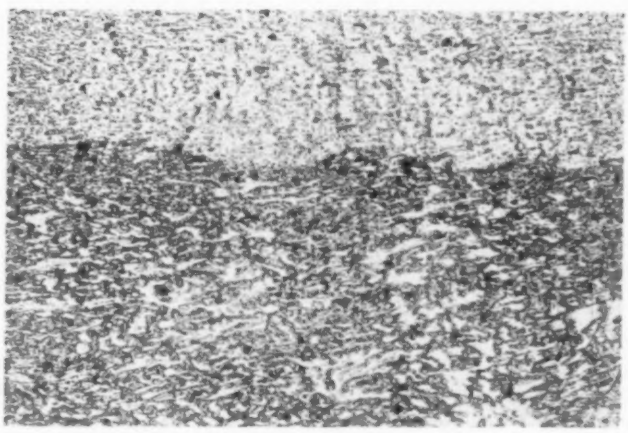
The dark constituent, the composition of which is not definitely known, contains copper, iron, and manganese.

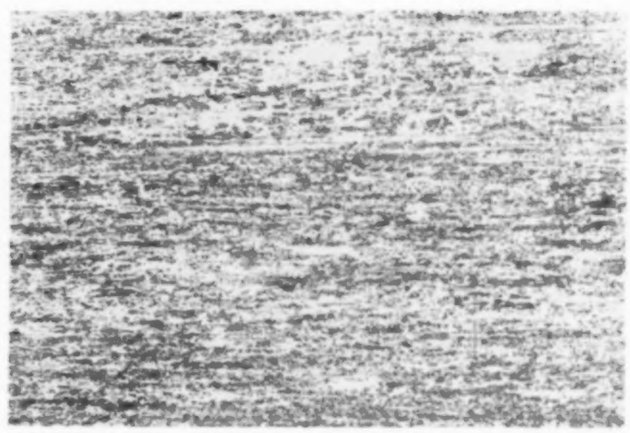
Typical Composition

Copper	4.4%
Iron	0.6
Silicon	0.8
Manganese	0.8
Aluminum	Balance

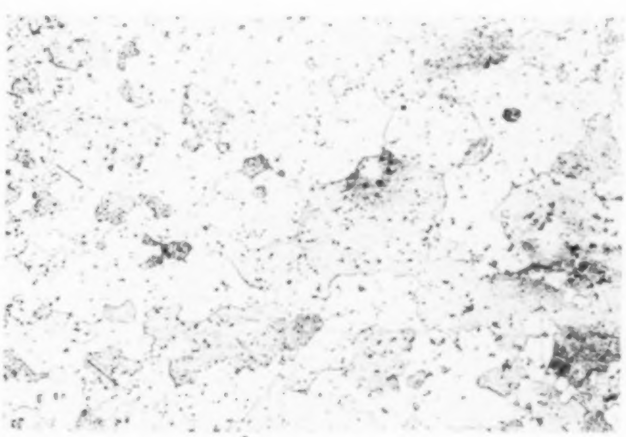
—

Aluminum Co. of America's No. 25S Alloy



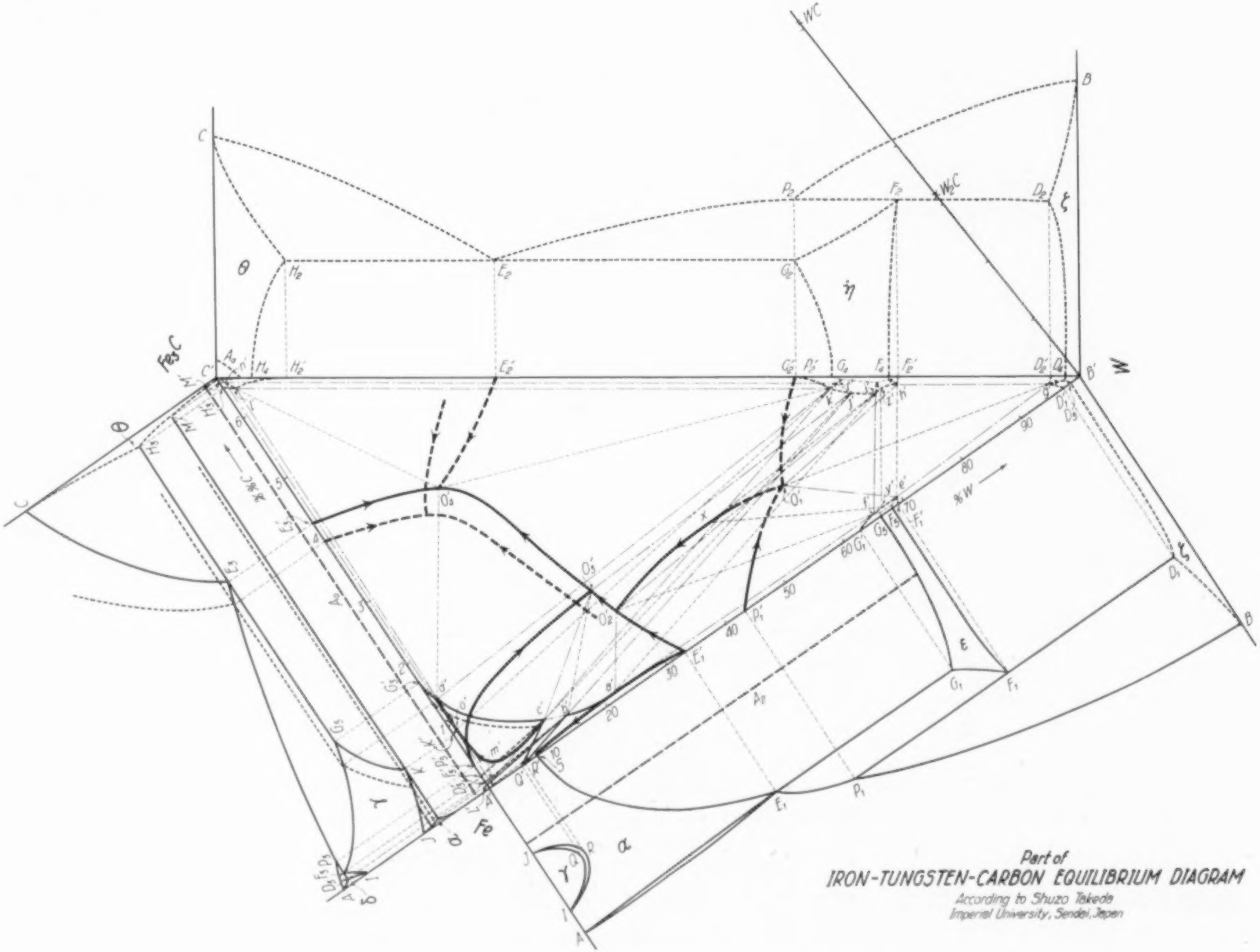


Transverse and Longitudinal Sections of Forged Billet After About 90% Reduction. Magnification 100 diameters. Shows small globules of $CuAl_2$ and fine microstructure. Intersection of two dendritic grains appears in the transverse section; elongated longitudinal structure is representative of well-worked material.



Transverse and Longitudinal Sections of Forged and Heat Treated Material. Magnification 100 diameters. Insoluble constituent is broken up and drawn out in the direction of work. It appears as small dark specks in transverse section. All of the $CuAl_2$ is in solution. Recrystallization produces substantially equiaxed grains.

Photomicrographs by Aluminum Research Laboratories



Part of
IRON-TUNGSTEN-CARBON EQUILIBRIUM DIAGRAM
According to Shuzo Takeda
Imperial University, Sendai, Japan

consists of copper .5% to 5.%; magnesium .1% to 1.7%; nickel .2% to 1.5%; iron .6% to 1.5%; silicon .55% to 2.8%; titanium up to .3%; manganese up to .3%; aluminum the remainder, and metallic sodium not exceeding .01%.

Pickling Stainless, *by Nathan H. Schermer, of Youngstown, Ohio. 1,824,932; Sept. 29.*

This pickling solution for stainless steels contains an alkali of metal nitrate, such as sodium or potassium nitrate, varying from about 0.2% to 40% by weight of the solution, a mineral acid, such as sulphuric or nitric, varying from 0.2% to 40% by weight of the solution, and water sufficient to make up a balance. A preferable solution contains 1% to 5% of sodium or potassium nitrate, and about 1% to 5% of sulphuric or nitric acid. The temperature of the pickling bath may be between 100° and 180° F., with the higher temperature preferable.

Cutting and Abrasive Material, by Elmer *B. Welch, McKeesport, Pa., assignor to the Firth-Sterling Steel Co. 1,822,426; Sept. 8. Also Patents 1,826,454, 1,826,455, 1,826,456, 1,826,457, by Gregory J. Comstock, Pittsburgh; Oct. 6.*

These patents all relate to a composition having abrasive characteristics and made with a suitable binding agent. Such product comprises principally tungsten carbide with some suitable binding agent, and in the first patent the tungsten carbide is bonded by an alloy of cobalt and copper, the copper consisting of from 0.2% to 20% by weight of the cobalt, and the tungsten carbide consisting at least 80% by weight of the composition. The second patent refers to a silicon carbide bonded in a matrix of nickel in which the silicon carbide consists of from 80% to 95% of the weight of the aggregate. The third patent describes a sintered aggregate comprising finely divided tungsten carbide particles embedded in a matrix of high speed steel. The fourth patent describes a sintered aggregate of finely divided vitrified zirconium oxide bonded in a matrix of nickel, the zirconium oxide consisting of from about 80% to 95% of the aggregate. The last patent covers a cutting composition of zirconium oxide bonded in a high speed steel in which the zirconium oxide consists of about 95% of the composition.

Core Oils, *by Edward H. McArdle, of Elizabeth, New Jersey, assignor to A. Klipstein and Co., of New York. 1,822,411; Sept. 8.*

Foundry cores can be made with a less costly oil having a lower iodine number, such as of the semi-drying class, including oils such as corn oil, soy bean oil, and sunflower oil. If a resin having a much greater acid value than rosin is substituted for the rosin and heated with the oil it will be found that the binding powers of the resultant core oil are equal to the previously known oils. Such an oil may have the formula as follows: 3 lb. of crude corn oil and 2 lb. of ester gum heated to a temperature of 560° F. for 30 min., holding at the temperature for 10 min. and then adding 1¾ lb. of cold low viscosity paraffin oil. After cooling add ¾ lb. of mineral spirits. The product is one gallon of core oil.

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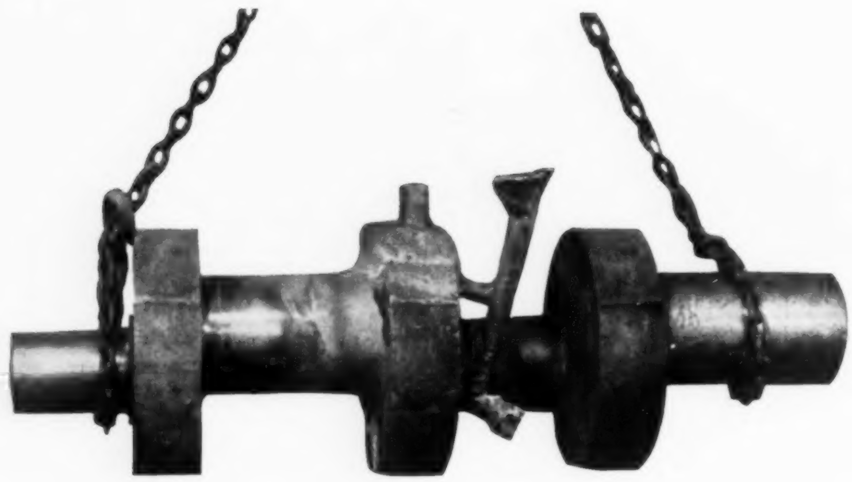

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